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THE GROUP OF SELAGINELLA OREGANA IN NORTH AMERICA

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With two plates

THE SUBGENUS *Euselaginella*[1] of *Selaginella* is one of those groups in which, apparently, mutation is easy and migration difficult. The result, or, more accurately, the existing condition, is a large proportion of local populations which differ minutely and sometimes rather by recombinations of certain stock characters than by individual and distinctive traits. These populations are difficult to group into sectional divisions or into nexi of species and varieties. They are often widely variable within themselves in such features as length and number of cilia and length of seta, but they show little intergradation with each other. I have seen only one instance of anything which looks like hybridization. Most of them occupy relatively restricted areas. Years ago Professor Fernald and I found similar conditions in *Puccinellia;* now, as then, the only possible taxonomic course is to describe the existing populations as species and make as valiant an effort as one can to arrange and key them out — though a dichotomous key in a group where there are no well marked divisions is no easy assignment.

The group of *S. oregana,* as here limited, is characterized by its lax, prostrate habit, usually elongate, slender stems, relatively distant branches, and appressed to strongly ascending leaves. The plants form loose, intricate mats. So far as can be made out from herbarium specimens, both stems and branches remain horizontal when growing on the ground, only the strobiles tending to assume an upright position.[2] The main stems are

[1] Selaginella subg. Euselaginella Warb. Monsunia 1: 100 (1900). Subg. *Homoeophyllum* Hieron. in Engler & Prantl, Nat. Pflanzenf. I. 4: 669 (1901). Although Hieronymus's name is derived from Spring's Sect. *Homoeophyllae* (Monog. Lycopod. 2: 53 [1849]), Warburg's is technically preferable as the first to be used in subgeneric rank and in proper form for that rank.

[2] Mr. U. T. Waterfall, however, tells me that in at least one patch of *S. mutica* in west Texas the branches are upright.

usually, with the leaves, not over 1 mm. in diameter; the more densely leafy new branches are often thicker. In dried specimens the leaves are almost always rather closely appressed; their behavior when boiled out, however, suggests that in life they assume an ascending position in wet weather. Standley (Amer. Fern Journ. 5: 78 [1915]) states that they do in New Mexican species. Only in *S. mutica* and *S. cinerascens* do the leaves remain appressed after boiling.

So defined, the group corresponds roughly to *S. rupestris β tropica* Spring, Monog. Lycopod. 2: 57 (1849) — a name under which Spring cited no specimens and which cannot be definitely applied, but under which he placed those portions of the all-inclusive *S. rupestris* of his time which had a lax and sprawling habit. Hieronymus, though using upright habit as the basis of a primary division, made no distinction between species with short, creeping stems and close-set, assurgent branches and those of the present group. I may at once admit that the revival of Spring's division is more a matter of convenience than of obvious affinity. There are nodes of affinity within the group: *S. oregana* and *S. Underwoodii* seem to be related (however far apart they come in the key); so do *S. mutica* and *S. viridissima*. *Selaginella Sartorii, S. Hintonii* and *S. Arsenei* quite certainly belong together; in foliar characters, *S. porrecta* seems to go with them, though its spores of both sorts are wholly different. But the group as a whole rests on habit alone and its boundaries have to be drawn more or less arbitrarily.

They may cut across real relationships. *Selaginella mutica,* for instance, is in leaf-characters much more like the short-stemmed *S. Watsoni* Underw. than the species with which it is here associated. On the other hand, *S. Chrismari* Hieron., though prostrate, is in its densely leafy, relatively thick stems, its pattern of branching, and its minute characters, so like the erect *S. rupincola* Underw. that it seems best left in that vicinity. *Selaginella Wallacei* Hieron. and *S. Hanseni* Hieron. occasionally produce long, prostrate stems; they are excluded because in both the strongly prevailing tendency is to form close mats with assurgent branches. Anyone attempting to name specimens by the present treatment should bear in mind that there are such borderline species and that they may not be accounted for here. If this paper adds somewhat to the understanding of the species included, that is all that can be hoped for it.

In any division of *Selaginella* based on habit parallel leaf- and spore-variations will be found in different groups. But in any division based on leaf- or spore-characters parallel variation in habit and other features will be found to quite as great an extent. And, as a primary basis for systematic arrangement, habit has very real and practical virtues — so much so that, within the two great homophyllous and heterophyllous subgenera, it has been used by all taxonomists up to the present time. Moreover, in subg. *Euselaginella* at least, divisions based on it fall into distinctive and reasonable geographic groups. That of *S. rupestris* proper (with short, prostrate stems, assurgent branches and more or less spreading leaves) includes by far the greatest number of species and occurs everywhere in the range of

the subgenus except the extreme north and extreme south. The more specialized small group of *S. Parishii* Underw., like the preceding, but with somewhat dimorphic leaves, is confined to the arid regions of the southwestern United States, from southwestern Texas to southern California, and northern and central Mexico. The present group has a mainly north-and-south distribution in the region of the North American Cordillera from Colorado to southern Mexico, with two outlying species on the Pacific coast, and reappears in southern Brazil, Uruguay, Paraguay and northern Argentina. This holds, whether the border-line species are included or not. The group with upright, shrub-like habit has, on the contrary, a generally east-and-west range, from the Piedmont and Coastal Plain of the southeastern United States in a narrow belt through western Texas, the southern half of New Mexico and Arizona and adjacent Mexico, to southern California.

In the taxonomic treatment which follows, descriptions of individual species are merely supplementary to the key and include no characters mentioned in it. Measurements are intended to give average dimensions; they may not cover extremes. Bibliography is meant to include only references to original descriptions and to literature which adds illustration or further information to the originals. In the key, the characters of number and length of cilia and length of terminal setae, much used by Hieronymus, have been for the most part omitted or stated in general terms. Cilia are easily broken off in dried material, so that an accurate count of them is difficult; and the length both of cilia and setae varies so much within species and even in the same colony that an attempt to find other characters which, even if seemingly incapable of altogether definite statement, could be more easily seen and better relied upon, seemed worth while. The type of cilia, whether narrow-based and hair-like or broad-based and more or less dentiform, their texture, and the texture of the setae, whether hyaline, subtranslucent and somewhat colored, or chalk-white and opaque, may well prove more significant than measurements. In all the species, the leaves are broadly sessile, the sometimes swollen base containing spongy mesophyll through which the single vascular strand makes its way into the blade. The shape and degree of adnation of these leaf-bases and the relative thickness of the blade, as well as its shape, seem also to be significant. Characters of the megaspores need to be used with some caution, since the depth and appearance of their sculpturing varies considerably with age; but its pattern is constant within species and aids greatly in defining them and in fortifying one's confidence in their validity.

The microspores offer equally distinctive characters, but mature ones are not easy to find. Those adhering to herbarium specimens or dissected out of sporangia are often still clinging together in their original tetrads and frequently covered with, and their sculpture-patterns obscured by, a dark, wrinkled membrane, presumably the persistent wall of the mother-cell. Fragments of this membrane often remain attached to the spores after they have separated from the tetrad; Hieronymus says it is permanently persistent in *S. lepidophylla*. In the present group, I have not seen it in

S. *Underwoodii* or *S. mutica* and scarcely in *S. oregana* and *S. extensa*. In the other species, it is a conspicuous feature; but whether this means that it is really longer persistent in them, or is merely due to accident, I cannot determine.

The key, an experiment in using the characters above indicated, is in part, for practical reasons, artificial. To use it most effectively, material should be examined under magnifications of 20–50 diameters for leaves, etc., 300–400 for microspores.

In addition to the material in the Gray Herbarium (G), I have seen all that in the Herbarium of Yale University (Y), and all the specimens of *S. mutica* and all those from Mexico in the United States National Herbarium (US).

I am much indebted to my wife for the accompanying drawings, to Prof. Hempstead Castle for the loan of specimens from the Eaton Herbarium at Yale University, to Mr. C. V. Morton for friendly and helpful criticism, and to Dr. William R. Maxon for loans from the United States National Herbarium and in many other ways. The attentive reader will observe that at various points I have merely followed in his foot-steps.

Key to the Species and Varieties

a. Leaves soft and thick, strongly convex dorsally, long-adnate (up to ¼ their length) at the cuneate base, with a short, hyaline terminal seta and few, short, mostly dentiform marginal cilia; sporophylls not strongly differentiated from the foliage-leaves; commissural ridges of megaspores connected near base by cross-ridges .... 1. *S. oregana*.

a. Leaves short-adnate at the usually rounded or truncate base; sporophylls conspicuously differentiated from the leaves; commissural ridges of megaspores connected at their apices by an equatorial ring or free. *b*.

  b. Leaves oblong-, elliptic-, or ovate-lanceolate, thick and strongly convex dorsally, especially at the cucullate apex, at least on new growth mostly 1.6 mm. or less long. *c*.

    c. Cilia of the foliage-leaves long, weak and spreading; sporophylls definitely ciliate. *d*.

      d. Leaves muticous or at most short-mucronate .... 3. *S. mutica*.

      d. Leaves with a terminal seta up to 0.4 mm. long.... 3a. *S. mutica* var. *texana*.

    c. Cilia, at least the upper, short, stiff, strongly ascending; sporophylls merely short-fimbriate; leaves with a short (0.2 mm. or less) terminal seta......... .... 3b. *S. mutica* var. *limitanea*.

  b. Leaves subulate- or oblong-linear, mostly more than 1.6 mm. long. *e*.

    e. Leaves with a short, flat hyaline apex or wholly muticous; cilia few and short. *f*.

      f. Leaves bright green, somewhat thickened; stems lax, forming a loose mat; megaspores finely reticulate-rugose. *g*.

        g. Leaves oblong-linear, acute or obtusish, quite without modified apex, rounded or narrowed at base, as seen in profile passing obliquely into the stem; megaspores subglobose with short, slender commissural ridges and no equatorial ring.................................... 4. *S. viridissima*.

        g. Leaves subulate-linear, acuminate, with a short, flat, outwardly bent hyaline apex, abruptly truncate at base; megaspores flattened, with prominent commissural ridges and a strongly and irregularly tuberculate equatorial ring.. 5. *S. extensa*.

f. Leaves glaucous, thin and papery, with an obtusish, minutely serrulate, hyaline or herbaceous apex; stems forming a closely prostrate mat; megaspores coarsely reticulate-rugose on outer face, with a prominent, thin, irregular equatorial ring....................................6. *S. cinerascens.*

e. Leaves with a straight, hyaline terminal seta. *h*.

h. Leaves abruptly truncate at base, thin and firm, nearly plane on both surfaces. *i*.

i. Cilia hyaline, 0.1 mm. or less long, ascending. *j*.

j. Leaves glaucous-green; cilia relatively few and distant. *k*.

k. Leaves subulate-linear, long-acuminate, commonly with a tuft of hairs at base; cilia piliform except near apex of leaf; outer face of megaspores coarsely reticulate-rugose................7. *S. porrecta.*

k. Leaves oblong-linear, short-tapering to apex, usually without hairs at base; cilia reduced to minute teeth; outer face of megaspores very finely and shallowly reticulate.......................8. *S. Arsenei.*

j. Leaves green; cilia numerous, piliform, strongly ascending; megaspores finely reticulate....................................9. *S. Hintonii.*

i. Cilia chalk-white, subopaque, piliform, laxly ascending or the basal spreading, up to 0.18 mm. long; outer face of megaspores reticulate with areoles of moderate size...............................10. *S. Sartorii.*

h. Leaves rounded or abruptly narrowed at base, thickened and dorsally convex, in profile passing obliquely into the stem; megaspores as in no. 10. *l*.

l. Seta 0.3–0.5 mm. long; cilia often reduced to small teeth or nearly obsolete...2. *S. Underwoodii.*

l. Seta 0.8–1.8 mm. long; cilia tending to become well developed and piliform.........................2a. *S. Underwoodii* var. *dolichotricha.*

1. **Selaginella oregana** D. C. Eaton in Wats. Bot. Cal. **2**: 350 (1880); Maxon in Amer. Fern Journ. **11**: 35 (1921), in Abrams, Ill. Fl. Pacific States, **1**: 48. *fig. 103* (1923). Plate I, 1.

Selaginella struthioloides (Presl) Underw. in Bull. Torr. Bot. Club **25**: 132 (1898), as to plant, not *Lycopodium struthioloides* Presl; Frye & Jackson in Amer. Fern Journ. **3**: 75. *pl. 3, fig. 4* (1913).

Stems very long, up to 9 dm. (according to Mrs. Summers "1–6 ft.," but this may refer to the dimensions of the mat rather than to individual stems). Leaves green, subulate-lanceolate, 2–2.6 mm. or more long, 0.5–0.6 mm. wide, acuminate, flat on the ventral surface, with a broad, conspicuous dorsal furrow. Seta nearly smooth, 0.3 mm. or less long, whitish or yellowish. Spikes up to 3 cm. long. Sporophylls similar to foliage-leaves, but broader, 2.2–2.4 mm. long, 0.8–1 mm. wide, scarcely biauriculate at base, long-acuminate, the cilia and seta as in leaves. Megaspores yellow, about 0.4 mm. in diameter, more or less flattened, shallowly reticulate on the outer face with areoles of moderate size, somewhat more strongly and less regularly reticulate on the commissural face, without an equatorial ring, but with a band of rather close reticulation, the rugae showing as irregular projections when seen in profile. Microspores about 50 μ in diameter, irregularly rugulose, with an irregular, rather broad wing.— Northern California, Oregon and Washington, near the coast; pendent from trees or on rocks.

Lectotype: Port Orford, Curry Co., Oregon, 1855, *Kautz* in herb. Yale University (dupl. G). After the custom of his time, Eaton designated no type. He cited two collections, that of Kautz and one from Tillamook Valley, Oregon, 1878, *Mrs. Summers 2209*. The former was incidentally designated as type by Maxon, Amer. Fern Journ. **11**: 36 (1921), and this designation may stand, though the Summers specimen is better

fruited and has more mature spores. Eaton wrote on his sheet of it: "Macrospores detected March 15, 1880!!! D. C. E." The Kautz specimen is better vegetatively.

The following specimens may be cited as representative. CALIFORNIA: near Adams, Del Norte Co., *Eastwood 12185* (G). OREGON: hanging from moss of trees, Coos River, Oct. 29, 1881, *Pringle* (G, Y); on maple trees by the Trask River, July 12, 1882, *Howell* (G, Y); without locality, 1871, *Hall* (Y). WASHINGTON: shaded ledges, base of Mt. Col Bob, Gray's Harbor Co., *Thompson 9399* (G); rocks, banks of Columbia River at Altoona, Wahkiakum Co., *Suksdorf 6811* (G); Leban, Pacific Co., *Piper 3802* (G); "Observatory Mt.," *Scouler 335* (G).

2. **Selaginella Underwoodii** Hieron. in Engler & Prantl, Nat. Pflanzenf. I. 4: 714 (1901); Underw. in Fern Bull. 10: 11 (1902); Standley in Amer. Fern Journ. 4: 114 (1914), 5: 78 (1915); F. C. Greene, op. cit. 17: 129 (1927); Maxon, op. cit. 27: 111 (1937); Wherry, op. cit. 28: 30 (1938). PLATE I, 2(A–F).

Selaginella rupestris var. *Fendleri* Underw. in Bull. Torr. Bot. Club 25: 127 (1898).

Selaginella Fendleri (Underw.) Hieron. in Hedwigia 39: 303 (1900), not Baker (1887).

Stems mostly less than 15 cm. long. Leaves loosely imbricate, oblong-linear, 2–2.5 mm. long, 0.3–0.4 mm. wide, the dorsal groove not reaching the somewhat thickened and subcucullate, obtusish apex. Seta scabrous. Sporophylls ovate-deltoid, about 2 mm. long and 1 mm. wide, subabruptly narrowed above the broad, widely biauriculate base to the acute, somewhat thickened and cucullate apex; dorsal groove not reaching the apex; seta as in foliage-leaves; margins densely or sparsely ciliolate-serrulate with often dentiform cilia. Megaspores about 0.3 mm. in diameter, somewhat flattened, shallowly and rather regularly reticulate on the outer face with thin ridges forming areoles of moderate size, more closely and irregularly sculptured on the commissural face with thicker ridges; commissural ridges prominent; no equatorial ring. Microspores about 50 μ in diameter, nearly smooth on the commissural face, finely and regularly punctate on the outer, with a narrow, irregular wing. — Wyoming, Colorado, western Oklahoma, southwestern Texas, northern New Mexico and northern Arizona. Presumably on rocks, often associated with *S. mutica*.

TYPE: *Fendler 1024* from near Santa Fe, New Mexico, in herb. New York Bot. Gard.; isotype, G.

The following are representative. COLORADO: Royal Gorge, Fremont Co., July 30, 1888, *Demetrio* (G); Minnehaha Falls, Pike's Peak region, El Paso Co., *Johnston 2421, 2425* (G). TEXAS: Mt. Livermore, Davis Mts., Jeff Davis Co., Aug., 1938, *Hinckley* (G). NEW MEXICO: moist cliffs, Ute Park, Colfax Co., alt. 2200–2900 m., *Standley 14688* (G). ARIZONA: near Flagstaff, Coconino Co., 1921, *Ferriss* (G, US).

2a. **Selaginella Underwoodii** var. **dolichotricha** var. nov. PLATE I, 2(G).

A varietate typica differt seta terminali foliorum 0.8–1.8 mm. longa, ciliis saepius bene evolutis piliformibus.

NEW MEXICO: Mogollon Creek, Mogollon Mts., alt. about 8000 ft., Socorro Co., July 20, 1903, *Metcalfe 276*, TYPE in Gray Herb.; Silver City, Grant Co., alt. 5700 ft., *Metcalfe 711* (US); Lookout Mine, south end of the Black Range, alt. about 8600 ft., Sierra Co., *Metcalfe 991* (G). ARIZONA: Frye Canyon, Pinaleno Mts., Graham Co., alt. 5500 ft., *Maguire, Richards & Moeller 11745* (G); Paradise, Cochise Co., March, 1904, *Ferriss* (G); Santa Rita Mts., Pima Co., *Goodding 5* (US). Specimens from Cave Creek, Chiricahua Mts., Cochise Co., Arizona, *Ferriss* in 1904 (US), and from the Organ Mts., New Mexico, *Wooton*, March 3, 1907 (US), though best placed under the variety, represent phases more or less intermediate in length of seta and in association of long seta and cilia.

Although the variation in length of seta and cilia is no greater than in

some other species, *S. arizonica* for instance, there seems to be here sufficient geographic segregation to justify the recognition of a variety, parallel to *S. mutica* var. *limitanea*. Long setae appear to occur consistently, and only, in the southern part of the range of the species; and long cilia are much more common there, though the association of the two is by no means constant.

3. **Selaginella mutica** D. C. Eaton in Underw. in Bull. Torr. Bot. Club 25: 128 (1898); Underw. in Fern Bull. 10: 10 (1902); Wherry in Amer. Fern Journ. 28: 136 (1938). PLATE I, 3(A–F).

Stems rather short for the group (10 cm.), forming a relatively dense mat. Leaves pale green, variable in size, 1–2 mm. long, 0.4–0.5 mm. wide, obtuse or acutish. Spikes up to 1.5 cm. long. Sporophylls ovate-deltoid, 1.4 mm. long, 0.6–0.8 mm. wide, evenly narrowed from above base to a normally mucronate acute apex. Megaspores subglobose, orange-yellow, finely and irregularly reticulate on both faces or nearly smooth on the outer, with low, short commissural ridges and low, inconspicuous ring or none. Microspores about 50 μ in diameter, very lightly granular or smooth, narrow-winged. — On rocks of various kinds (limestone, basalt and sandstone are mentioned by collectors), montane regions of Colorado, eastern Utah, southwestern Texas, northern and central New Mexico, and northern Arizona, with a single record from the southeastern part of that state.

As LECTOTYPE I would choose a specimen in herb. Yale University collected in "crevices of rocks, mountains of Colorado, 1871" by *Meehan*. In publishing the species from Eaton's manuscript, Underwood designated no type. Of the specimens in Eaton's herbarium, the only one labelled *S. mutica* is a fragment without data of locality. The cited specimen of the Mexican Boundary Survey is of the phase here treated as var. *texana*. Presumably Eaton overlooked the inconspicuous and fragile terminal seta present in this collection, though often broken off in the older leaves. In any case, his description and the name he chose preclude the choice of a setigerous specimen as type. The cited specimen which he seems especially to have studied and from which he made a drawing of a leaf, is the Colorado one collected by Meehan. I am accordingly regarding that as the type.

The following are representative. COLORADO: Estes Park, Larimer Co., 2250 m., July 20, 1914, *Wooton* (US); Idaho Springs, Clear Creek Co., alt. 13000 ft., *Shear 4616* (US); columnar basalt cliffs southwest of Lyons, Boulder Co., June 20, 1937, *Wherry* (US); Manitou, El Paso Co., Dec., 1924, *Goldsmith* (G); same locality, shallow soil covering limestone, piñon belt, alt. 6600 ft., *Johnston 3871* (US); canyon of Arkansas River, Fremont Co., *Bacigalupi 1015* (G), July 31, 1888, *Demetrio* (G); Canyon City, 1871, *Brandegee* (Y); rocks in canyon, San Miguel River near Gateway, Montrose Co., *Maguire & Piranian 11371* (G); shaded gulch in dry, rocky hills, alt. 5800 ft., Paradox, *Walker 365* (G, US). UTAH: Vernal, Uintah Co., *Graham 7592* (US); under and about rocks, canyon and talus slopes, head of Calf Spring Wash, San Rafael Swell, Emery Co., 6800 ft., *Maguire 18450* (G). TEXAS: Sierra Diablo, Hudspeth Co., Sept. 13, 1921, *Goodding* (US); El Paso, *Mearns* (US); calcareous soil in crevices of limestone ledges, Victoria Canyon, Sierra Diablo, *Waterfall 4811* (G). NEW MEXICO: Sierra Nacimento, Rio Arriba Co., *Goodding 6142* (US); Rio Grande Canyon, west of Taos, Taos Co., *Wilkens 2422* (US); Nambe Creek, Santa Fe, *Arsène 21118* (G); on rocks in woods along Pecos River, Pecos, San Miguel Co., *Drouet & Richards 3311* (G, US); Santa Rosa, Guadelupe Co., 1450 m., *Arsène & Benedict 16643* (US); sandstone cliffs south of Grant's, Valencia Co., May 18, 1939, *Goodding* (US); Magdalena Mts., northwest of Socorro, Oct., 1922, *Ferriss* (US). ARIZONA: near Betatakin ruins, Navajo Co., *Wetherill 536* (US); on and about exposed rocks (sandstone?) near rim of canyon, Grand Canyon, Coconino Co., alt. 6500 ft., Nov. 17,

1905, *Wm. Palmer* (US); Chiricahua Mts., Cochise Co., Sept. 20, 1896, *Toumey* (US, Y).

There is much variation in the leaves of *S. mutica*. Typically, those of the new growth are oblong-lanceolate or even ovate-oblong in outline, closely imbricated, obtuse and not more than 1.4 mm. long. This condition grades into one in which the leaves of the new growth are ovate-lanceolate, rather loosely imbricate, tapering to an acute apex, 1.8–2 mm. long and more often mucronate. The two extremes are striking enough to the eye, but taxonomically are inextricable (though Hieronymus gave a manuscript name to a sheet of the second). Not only are there various intermediates, but the two frequently occur in the same collections and even in the same colonies and have no regional differentiation. Some of the long-leaved plants show a tendency to develop narrowed and lengthened leaf-bases suggestive of hybridization with *S. Underwoodii*, which frequents the same habitats as *S. mutica* and not uncommonly grows intermingled with it. Such hybridization may be an element in the variability of the plants here considered as belonging with typical *S. mutica*.

Two other variants show geographic segregation and may profitably be set apart as varieties.

3a. **Selaginella mutica** var. **texana** var. nov.

A varietate typica differt foliis sporophyllisque seta terminali laevi albescente hyalina ad 0.4 mm. longa praeditis.

TYPE: shaded rocky hillside, ridges south of Emory Peak, Chisos Mts., Brewster Co., Texas, alt. 2300 m., June 23, 1931, *Moore & Steyermark 3196*, in Gray Herb.; isotype, US.

Other specimens seen — TEXAS: "Mexican Boundary" (Y); Pulliam Canyon, *Sperry 428* (US); moist cliffs and crevices, rhyolite cliffs, north exposure, near Mt. Livermore, Davis Mts., alt. 2400 m., *E. J. Palmer 30871* (G); exposed rock crevices, Little Ajuga Canyon, Davis Mts., alt. 1495 m., *Moore & Steyermark 3046* in part (G, US); Limpia Canyon, *Tracy & Earle 275* (G, US; toward var. *limitanea*).

This is a rather indefinite variety, combining the long, spreading cilia of typical *S. mutica* and the terminal seta of var. *limitanea*, and known only from west Texas where the ranges of these two meet. Morphologically, it is little more than a series of intermediates between them, and one may doubt if it represents any established genetic line. Nevertheless, the specimens here brought together have a recognizable association of characters; the terminal seta is generally longer than in var. *limitanea;* and, from the standpoint of practical taxonomy, the recognition of the variety clarifies the arrangement of material.

Wright 2115, distributed with a label-caption reading "New Mexico," but actually collected at Frontera, in what is now El Paso County, Texas, represents an occasional variant of *S. mutica* toward var. *texana*. Some of its leaves have short setae, some do not.

3b. **Selaginella mutica** var. **limitanea** var. nov. PLATE I, 3(G).

A varietate typica differt foliis sporophyllisque seta terminali brevi (ad 0.2 mm. longa) fere laevi albescenti-hyalina praeditis, ciliis sparsis brevibus plerumque minus quam 0.1 mm. longis adscendentibus, sporophyllis eroso-fimbriatis.

TYPE: mountains west of Deming, Luna Co., New Mexico, Oct. 4, 1937, *Goodding* (US).

Other specimens seen — TEXAS: Mt. Franklin, El Paso Co., Dec., 1924, *Slater* (US); Ft. Davis, *Ingram 2723* (US; transitional); exposed rock crevices, Little Ajuga Canyon, Davis Mts., alt. 1890 m., *Moore & Steyermark 3046* in part (G); on sometimes wet ledges and cliffs of porphyritic rock, Mt. Livermore, Davis Mts., *E. J. Palmer 31951* (US), *Hinckley 1155* (US) (the last three localities in Jeff Davis Co.). NEW MEXICO: Van Patten's, Organ Mts., Dona Anna Co., Sept. 10, 1899, *Wooton* (US), June 9, 1906, *Standley* (US); Filmore Canyon, April 8, 1903, *Wooton* (US) and three other collections by *Wooton* from the Organ Mountains without more definite locality. ARIZONA: Paradise, Cochise Co., *Ferriss* (G).

This is a well-marked variant, morphologically and geographically, but it is connected by intermediates with var. *texana* and through it with typical *S. mutica*. I borrow from *Notholaena* Dr. Maxon's very appropriate epithet for a population occurring in a narrow strip of territory along the Mexican border.

The similarity in range between this variety and *S. Underwoodii* var. *dolichotricha*, as also between the typical forms of the two species, is apparent. Evidently there is, at least for these species, a phytogeographic break between northern and southern Arizona and northern and southern New Mexico west of the Rio Grande — a break which follows roughly the line of the mountain-mass which extends westward from the Sierra Mimbres, on the watershed between the Rio Grande and the Gila River, to the vicinity of Prescott, Arizona, and beyond at lower altitudes to the Colorado River valley, and which also forms the southern boundary of Fenneman's Colorado Plateau Province. East of the Rio Grande, where the mountain-ranges run north and south, the northern elements of both species run south to the Davis Mountains of Texas.

4. **Selaginella viridissima** Weatherby in Journ. Arnold Arb. 24: 326 (1943). PLATE I, 4.

Stems of moderate length, up to 10 cm. Leaves somewhat thickened and convex above, especially toward apex, 1.6–2 mm. long, 0.3–0.4 mm. wide, with sparse, very short (0.1 mm. or less long), ascending, mostly dentiform cilia, reduced to teeth toward apex. Spikes up to 1 cm. long. Sporophylls ovate-deltoid, 1.8–2 mm. long, 0.8–1 mm. wide, somewhat dilated above base, thence tapering evenly to the acuminate apex, the margins densely erose-serrulate with very short teeth. Seta none. Megaspores yellow, 0.4–0.5 mm. in diameter, subglobose or somewhat flattened on the commissural face. Microspores very regularly alveolate-punctate (at least on outer face), irregularly winged.

TYPE: shaded cliffs in deep canyon, in hanging mats 1 m. in diameter, Cañon de Calabasa, north wall of Sierra Mojada, Coahuila, Mexico, Oct. 27, 1941, *Stewart 2204*, in Gray Herb.

One other collection has been seen: mats on shaded cliffs, Tinajas del Osos, vicinity of Aguaje del Pajarito, west end of Sierra de la Fragua, 2–3 km. north of Porto Colorado, Coahuila, Sept. 1–8, 1941, *Johnston 8683*.

5. **Selaginella extensa** Underw. in Bull. Torr. Bot. Club 25: 131 (1898). PLATE I, 5.

Selaginella rupestris subvar. *viridis* Fourn. Mex. Pl. 1: 146 (1872), at least in part.

Stems elongate, up to 3 dm. long. Leaves appearing somewhat fleshy,

but not thickened at apex, 1.6–2 mm. long, 0.3–0.4 mm. wide, with few and distant, strongly ascending, very short, thick and dentiform cilia. Spikes 1–2 cm. long. Sporophylls narrowly deltoid, 1.8–2 mm. long, 0.5–0.6 mm. wide, long-acuminate, closely serrulate with short, thick, broad-based, pungent teeth; apex as in foliage-leaves. Megaspores densely and finely rugose on both faces, more strongly on the commissural. Microspores about 35 μ in diameter, coarsely and irregularly punctate, with a narrow, somewhat irregular wing, the mother-cell membrane soon shed, but the spores long adhering in tetrads. — Central Mexico.

TYPE: on rocks and trees, Las Canoas, San Luis Potosí, Mexico, Aug. 21, 1891, *Pringle 3900,* in Herb. New York Bot. Gard.; isotypes, G, US, Y.

Other specimens seen — SAN LUIS POTOSÍ: limestone cliffs, Las Canoas, alt. 900–1000 m., *Pennell 17947* (US). HIDALGO: shallow leaf-mold on dry rock, Jacala, alt. 5000 ft., *Hoogstraal & Chase 7308* (US), *Frye 2537* (US). VERA CRUZ: old trees, Sierra Madre, Naolinco, *Purpus 6052* (G, US); région d'Orizaba, Oct., 1865–66, *Bourgeau 2541* (G, Y); Borrego, Orizaba, June 19, 1865–66, *Bourgeau 2541* (G); ad arborum truncos repens in sylvis umbrosis humidis, Cordoba, Sept., 1856, *Mohr 12* (Y).

Selaginella extensa is a very well marked species, set apart from all others of its alliance by its peculiar flattened and spreading leaf-tips and its equally peculiar, equatorially tuberculate megaspores.

6. **Selaginella cinerascens** A. A. Eaton in Fern Bull. 7: 33 (1899); Maxon in Abrams, Ill. Fl. Pacific States, 1: 47. *fig. 102* (1923); Munz, Man. So. Cal. Bot. 13 (1935); Munz & Johnston in Amer. Fern Journ. 13: 3 (1923); Wiggins, op. cit. 22: 92 (1932). PLATE II, 6.

Stems not greatly elongate (at most 15 cm.) and rather closely branched. Leaves oblong-linear, about 2.4 mm. long and 0.4–0.5 mm. wide. Cilia strongly ascending, mostly few and irregularly spaced, very short (0.1 mm. or less long), but not dentiform. Spikes short, about 5 mm. long. Sporophylls broadly deltoid, about 1.8 mm. long by 1.2 mm. wide, broadly acuminate, without a seta, finely and densely ciliolate with very short ciliola. Megaspores pale yellow, lightly rugose on the commissural face. Microspores up to 50 μ in diameter, with delicate radiating striae on the commissural face, finely granular on the outer face, with a broad, entire wing. — Southern California and adjacent Baja California, on clay-banks, forming closely prostrate mats.

TYPE: National City, San Diego, California, *Miss L. F. Kimball,* in Gray Herb.

The following are representative: Mission Hills, San Diego, *Abrams 3399* (G); Ensenada, Baja California, *Johnston 3004* (US), *Wiggins 4213* (G).

The "prominent spinules" mentioned by A. A. Eaton in his description of the microspores I have observed only at the junction of the body of the spore and the wing; I believe they are to be interpreted as wrinkles in the spore-coat outlined by transmitted light rather than as actual spinules such as occur in *S. selaginoides.*

7. **Selaginella porrecta** sp. nov. PLATE II, 7.

Caules plerumque nec valde elongati, graciles foliis inclusis ca. 1 mm. diametro, prostrati, fere ad apicem radicantes, pinnatim alternatimque ramosi, ramulis vix ultra 1 cm. longis. Folia arcte adpressa, subulato-linearia, longe acuminata, pallide viridia, paginis ambobus plana dorso usque ad apicem sulcata, ea ramulorum ca. 2.5 mm. longa 0.4 mm. lata, ea caulis ad 3 mm. longa 0.5 mm. lata, nonnumquam basi fasciculo ciliorum

ornata, marginibus sparse breviterque ciliata, ciliis ca. 10 vel paucioribus adscendentibus versus apicem folii vel rarius ubique ad denticulos reductis, apice seta subhyalina albescente flavescenteve scaberula usque ad 1 mm. longa praedita. Spicae ad apices ramulorum gestae ca. 1 cm. longae. Sporophylla anguste deltoidea, ca. 2.2 mm. longa 0.8 mm. lata, e ⅓ longitudinis supra basim leviter auriculatam ad apicem acuminatum seta subhyalina albescente flavescenteve fere laevi 0.3–0.8 mm. longa ornatum gradatim angustata, marginibus basim versus dense breviterque ciliolatis ciliolis subdentiformibus 0.1 mm. vel minus longis. Megaspori ca. 0.4 mm. diametro subglobosi aurantiaci vel flavi, latere commissurali tenuius latere altero valde crasseque reticulato-rugosi, exannulati, costis commissuralibus prominentibus. Microspori aurantiaci, ca. 40–45 μ diametro, latere commissurali costis exceptis laeves, latere altero irregulariter plus minusve rugosi, ala crassa irregulari valde rugosa ornati. — Northeastern and north-central Mexico.

Type from red sandstone slope, alt. 1650–1700 m., "Alamar," Pablillo, southeast of Galeana, Nuevo León, July 2–3, 1934, *Pennell 17198* in U. S. Nat. Herb., sheet no. 1,685,291.

Other specimens seen — Nuevo León: La Silla Mt. near Monterrey, *Orcutt 1151a, 1142* (US); Topo Chico, near Monterrey, *Orcutt 1098* (US); Monterrey, *Tharp 1792* (US). San Luis Potosí: *Orcutt 5125* (US); thin soil over limestone, alt. 2100 m., Sierra de Alvarez, *Pennell 17753* (US); in montibus circa urbem San Luis Potosí, *Schaffner 933* (Y). Tamaulipas: Cerro de los Armadillos, vicinity of San José, alt. 2600 ft., *Bartlett 10355* (US); Cerro Zamora, vicinity of El Milagro, *Bartlett 11039* (US). Durango: Sianori, *Ortega 5319* (US).

Much of the material placed here was long ago indicated by Maxon as belonging to a new species but was not given a name. Its status is somewhat doubtful, for the reason that, of all the specimens cited, only the type has mature spores and on their characters the claim of the group to specific rank largely rests. These characters seem pronounced enough; the wing of the microspores, so wrinkled and folded as to suggest a ruffle on an old-fashioned gown, is particularly distinctive. But, should they prove inconstant or in the case of the microspores abnormal (though aside from the peculiarity of the wing, there is no evidence of abnormality), *S. porrecta* might have to be united with *S. Arsenei*, to which, as noted in the introduction, it is very similar in foliar characters, or reduced to a variety of *S. Sartorii.*

8. **Selaginella Arsenei** sp. nov. Plate II, 8.

Caules prostrati, cum ramis fere ad apicem radicantes, nec valde elongati (ad 15 cm. longi), foliis inclusis vix ultra 1 mm. diametro, pinnatim alternatimque ramosi; rami bene evoluti ad 7 cm. longi ramulis ad 1.5 cm. longis dense foliosis. Folia glaucescentia tenuia paginis ambobus plana dorso usque ad apicem anguste sulcata, subchartacea, arcte vel sublaxe adpressa, oblongo-linearia, 1.8–2.4 mm. longa, 0.35–0.4 mm. lata, in apicem acutum seta albescenti-hyalina scaberula ad 0.5 mm. longa ornatum subbreviter angustata, marginibus subsparse ciliato-serrulata, ciliis brevissimis plerumque dentiformibus. Sporophylla anguste deltoidea fere e basi levissime biauriculata ad apicem acuminatum seta albescenti-hyalina brevi ornatum gradatim angustata, marginibus dense ciliolato-serrulata. Megaspori subglobosi ca. 0.4 mm. diametro dense leviterque reticulato-rugosi, exannulati,

costis commissuralibus brevibus vix prominentibus. Microspori diametro 40–50 μ aurantiaci (luce transeunte flavi), latere commissurali, ut videtur, radiatim, latere altero irregularius rugulosi, ala angusta plana integra.

TYPE: Queretaro, Mexico, 1914, *Arsène 10641,* in U. S. Nat. Herb., sheet no. 1,000,066. Other specimens, same locality and collector: 1850 m. alt., 1911, *no. 9983;* 1914, *no. 10643,* both US.

This also was indicated by Dr. Maxon as a probable new species.

9. **Selaginella Hintonii** sp. nov. PLATE II, 9.

Caules graciles ad 30 cm. longi, foliis inclusis ca. 1 mm. diametro, repentes, cum ramis fere ad apicem radicantes, pinnatim alternatimque ramosi, ramis ad 8 cm. longis, ramulis plerumque simplicibus vix ultra 1 cm. longis dense foliosis. Folia subulato-linearia in caule ca. 2.5 mm. longa 0.4 mm. lata, in ramis ca. 2 mm. longa 0.3 mm. lata, acuta viridia, paginis ambobus plana, dorso usque ad apicem sulcata, arcte adpressa, marginibus dense ciliata ciliis brevibus numerosis (20 vel pluribus) valde adscendentibus albescentibus subhyalinis, apice seta albescente lutescenteve hyalina scaberula 0.6–0.8 mm. longa praedita. Spicae 1 cm. vel minus longae. Sporophylla anguste deltoidea ca. 1.8 mm. longa 0.8 mm. lata, fere e basi leviter biauriculata gradatim ad apicem acuminatum angustata, marginibus dense ciliolato-serrulata ciliis brevissimis subdentiformibus. Megaspori flavi subglobosi ca. 0.4 mm. diametro levissime reticulato-rugosi vel fere laeves, costis commissuralibus inconspicuis, inter amba latera non, vel non manifeste, annulati. Microspori lateribus ambobus plus minusve subalveolato-punctati, ala lata integra. — Known from the type collection only.

TYPE: cliffs, Ypericones, Dist. Temascaltepec, State of Mexico, Sept. 7, 1935, *Hinton 8423,* in Gray Herb.

Closely related to *S. Sartorii,* from which, however, it seems to differ sufficiently by the characters given in the key.

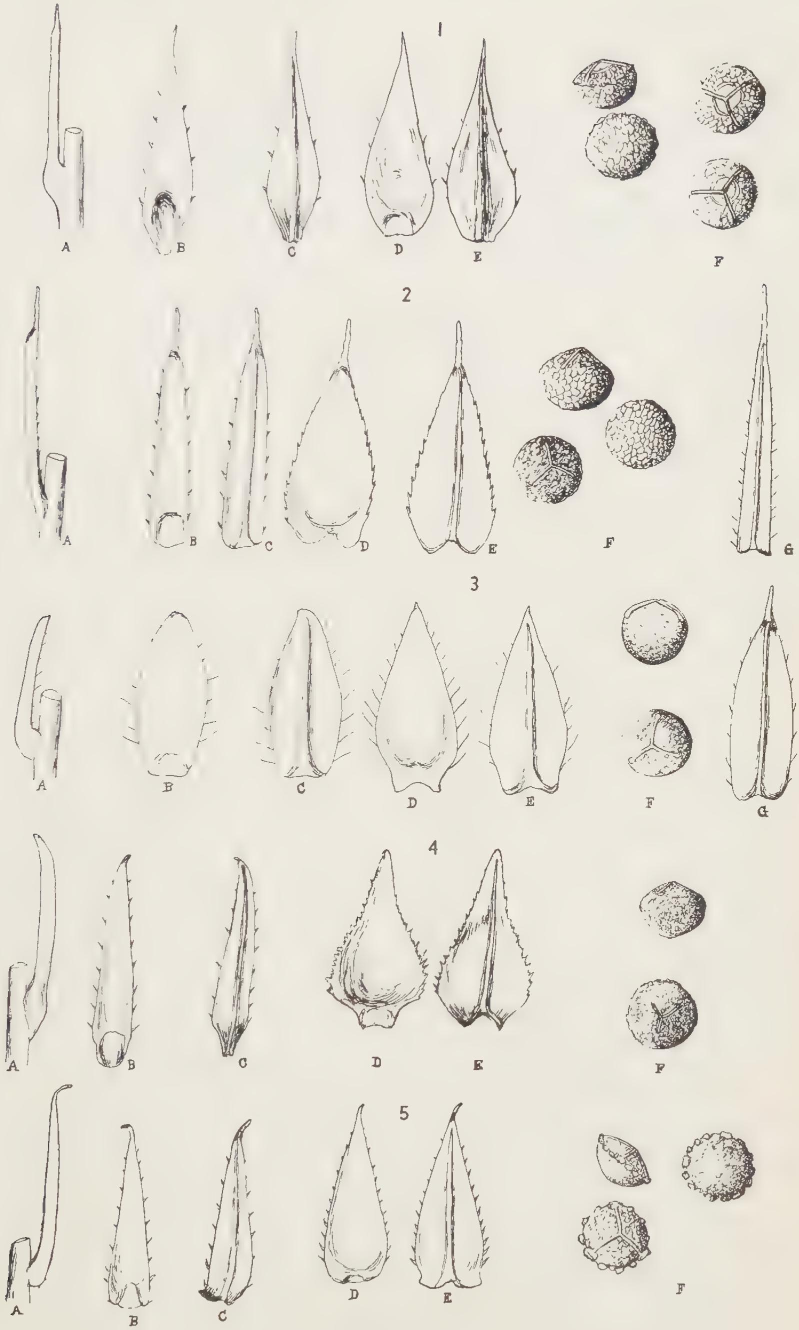
10. **Selaginella Sartorii** Hieron. in Hedwigia 39: 304 (1900). PLATE II, 10.

Stems elongate (in herbarium specimens up to 3 dm. long), lax, the branches mostly distant, forming loose mats. Leaves oblong-linear, acute or acuminate, about 2.2 mm. long on old stems, 1.5 mm. on branches, 0.25–0.3 mm. wide, so far as can be made out from dried specimens gray-green, often turning red. Spikes 1 cm. or less long. Sporophylls ovate-deltoid, 1.5 mm. long, 0.8 mm. wide, evenly acuminate from a point about ⅓ above base, below narrowed to the biauriculate base. Megaspores about 0.3 mm. in diameter, yellow, subglobose, irregularly rugose on the commissural face, rather regularly on the outer, the commissural ridges prominent. Microspores about 40 μ in diameter, minutely punctate or subreticulate on both faces, with a narrow, entire wing. — On rocks, central and southern Mexico.

Type not designated; the specimen cited from Mirador, Vera Cruz, Mexico, *Sartorius,* in the Berlin Herbarium (now probably destroyed) should be regarded as TYPE.

Other specimens seen — VERA CRUZ: in rupibus trachyticis prope Mirador, Aug., 1841, *Liebmann* (G); steinige Stellen, oberes Savannen-gebiet, 6–700 m. alt., Palmilla, *Purpus 120* (US), *8463* (G, US). OAXACA: prope Oaxacam, *Andrieux 2* (G).

What *Selaginella Aschenbornii* Hieron. in Hedwigia 39: 305 (1900) may be I do not know; but the description of the leaves as spreading indicates



Group of Selaginella oregana

Group of Selaginella oregana

that it is none of the species here considered. Similarly, the identity of *S. rupestris* var. *mexicana* Milde, Fil. Eur. 263 (1867), published without citation of specimens, can be determined only by examination of authentic material. Hieronymus seems to have considered it an aggregate, as it very probably was.

Arsène 891 and *10639* from Puebla, *Rose & Painter 6835* from Guadalupe, Valley of Mexico, and *Liebmann 2062* from Mirador, Vera Cruz, very likely represent another species of this group. They were marked as a probable new species by Dr. Maxon. I hesitate, however, to describe it, since all the specimens seen are without strobiles, and, though of distinctive appearance, may be only juvenile individuals.

EXPLANATION OF PLATES

Under each species, A is a foliage-leaf seen, somewhat diagrammatically, in profile; B and C, respectively, are ventral and dorsal surfaces of foliage-leaves; D and E, ventral and dorsal surfaces of sporophylls; F, megaspores, from the commissural face, in profile, and in some cases from the outer face also. The degree of magnification of leaves and sporophylls varies between × 12 and × 15; that of megaspores between × 25 and × 30.

Plate I

Fig. 1. *Selaginella oregana,* from *Eastwood 12185.* Fig. 2. *S. Underwoodii,* from isotype, *Fendler 1024;* G, var. *dolichoptera,* from type. Fig. 3. *S. mutica,* from *Maguire 11371;* G, var. *limitanea,* Cochise Co., Arizona, *Ferriss.* Fig. 4. *S. viridissima,* from type. Fig. 5. *S. extensa,* from *Bourgeau 2451.*

Plate II

Fig. 6. *Selaginella cinerascens,* from type. Fig. 7. *S. porrecta,* from type. Fig. 8. *S. Arsenei,* from type. Fig. 9. *S. Hintonii,* from type. Fig. 10. *S. Sartorii,* from *Purpus 8463.*

Gray Herbarium,
Harvard University.

NOTES ON THE FLORA OF SOUTHERN CHINA[1]

HUI-LIN LI

THE MATERIAL used in preparing these notes is, in part, that assembled through botanical explorations conducted in recent years by representatives of Lingnan University and the Botanical Institute of Sun Yatsen University with the coöperation of the Arnold Arboretum. This paper deals mainly with the flora of Kwangtung Province exclusive of the island of Hainan. Ten species and two varieties from Kwangtung and Kwangsi are herein proposed as new, while a number of previously described species are for the first time credited to one or both of these provinces. Two new species from adjacent parts of southern Kiangsi and southern Fukien are also included. The synonymy of a few other species is adjusted. All types of the new entities herein described are deposited in the herbarium of the Arnold Arboretum.

ROSACEAE

Pyracantha M. Roemer

Pyracantha Fortuneana (Maxim.) comb. nov.

Photinia Fortuneana Maxim. Bull. Acad. Sci. St. Pétersb. **19**: 179. 1873, Mél. Biol. 9: 179. 1873.

Photinia crenato-serrata Hance, Jour. Bot. **18**: 261. 1880, syn. nov.

Pyracantha crenato-serrata Rehder, Jour. Arnold Arb. **12**: 72. 1933, cum syn.

A photograph of a duplicate type of *Photinia Fortuneana* Maxim. from Kew (*Fortune A69,* 1845) and fragments of leaves and flowers in the herbarium of the Arnold Arboretum indicate that Maximowicz's species is not only a *Pyracantha* but that it is also the same as the form currently known as *Pyracantha crenato-serrata* (Hance) Rehder. The original descriptions of Maximowicz and of Hance are in full agreement. Among the other synonyms are *Cotoneaster Pyracantha* sensu Pritzel (1900) pro parte, non Spach, *Pyracantha crenulata* sensu C. Schneider (1906) pro parte, non Roemer, *Pyracantha crenulata* var. *yunnanensis* M. Vilmorin (1913), and *Pyracantha yunnanensis* Chittenden (1921). As Maximowicz's name is seven years earlier than that of Hance, a new combination is here effected. The exact locality of Fortune's specimen is not given, but most probably it was from the coastal regions of eastern China. The species is recorded from Shensi, Kansu, Szechuan, Hupeh, Yunnan, Kweichow, and Kwangsi.

Rubus Gressittii Metcalf, Lingnan Sci. Jour. **19**: 25. 1940.

KWANGTUNG: T'sung-hwa District, Sam Kok Shan, Ch'an Woh T'ung Village, *W. T. Tsang 25064,* May 1–25, 1935, a climber 4 ft. high, fairly common in swamps, flowers white, fruit edible; Jen-hwa District, *W. T. Tsang 26403,* May 21–30, 1936, a climber, 3 ft. high, fairly common in thickets, flowers white. Kiangsi. New to Kwangtung.

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Rubus pinfaensis H. Lév. & Vaniot, Bull. Soc. Agri. Sci. Arts Sarthe 39: 320. 1904, Repert. Nov. Sp. 6: 374. 1909; Focke, Bibl. Bot. 17[Heft 72]: 199. *f. 81.* 1911, et in Sargent, Pl. Wils. 1: 55. 1911; Rehder, Jour. Arnold Arb. 18: 50. 1937.

Rubus erythrolascius Focke, op. cit. 197. *f. 79.* 1911, syn. nov.

This species is of wide distribution in southern China. With a large series of specimens before me, I am convinced that the two supposedly different species are conspecific. The reduction of Focke's species is based on an examination of an isotype (*Henry 10583* of Lunan, Yunnan) in the herbarium of the Arnold Arboretum.

Rubus pinnatisepalus Hemsl. Jour. Linn. Soc. Bot. 29: 305. 1892; Focke, Bibl. Bot. 19[Heft 83]: 29. 1914.

Rubus calycanthus H. Lév. Repert. Sp. Nov. 8: 58. 1910, Fl. Kouy-Tchéou 357. 1915; Focke, Bibl. Bot. 19[Heft 83]: 34. 1914, sub *R. Labbei;* Cardot, Bull. Mus. Hist. Nat. Paris 23: 282. 1917; Hand.-Maz. Symb. Sin. 7: 494. 1913; Rehder, Jour. Arnold Arb. 18: 31. 1937, cum syn., syn. nov.

Rubus laciniatostipulatus Hayata ex Koidzumi, Jour. Coll. Sci. Tokyo 34(2): 154. 1913; Hayata, Ic. Pl. Formos. 3: 91. 1913, syn. nov.

Rubus echinoides Metcalf, Lingnan Sci. Jour. 19: 24. 1940, syn. nov.

An examination of type or authentic material representing all the above species indicates that they represent a single one for which Hemsley's name is the earliest. The species extends from Szechuan through southern China to Formosa. In addition to the type material of Léveillé's species cited by Rehder, who combines *Rubus calycanthus* var. *Buergerifolia* H. Lév., *R. Labbei* H. Lév. & Vaniot, and *R. Darrissi* H. Lév., all from Kweichow, *R. pinnatisepalus* Hemsl. from Szechuan (holotype, *Faber 505*) is represented by a photograph and fragments of flowers, *R. laciniatostipulatus* Hayata is represented by a topotype (*G. Shimada 116*) from Samkakuyu, Formosa, and *R. echinoides* Metcalf is represented by the holotype (*R. C. Ching 6679*) from Kwangsi in the herbarium of the Arnold Arboretum. Among the recent collections, *S. W. Teng 90780* and *90954,* from Kweichow, and *S. P. Ko 55665* from Kwangsi belong to this species.

Rubus kwangtungensis sp. nov. Subgenus *Idaeobatus,* § *Rosaefolii.*

Planta 0.6 m. alta, caulibus aculeatis glabris vel sparse setosis, setis glanduloso-stipitatis, aculeis minutis vix 1 mm. longis; foliis pinnatis, cum petiolis ad 30 cm. longis, petiolis rhachibusque glabris raro 1–2-aculeatis; petiolis circiter 7.5 cm. longis; stipulis linearibus, 3–4 mm. longis, petiolorum basi insertis; foliolis 7–9, sessilibus vel breviter (1–2 mm.) petiolulatis, membranaceis, lanceolatis, 9–10 cm. longis, 2–2.3 cm. latis, longe caudato-acuminatis, basi late acutis vel subrotundatis, margine simpliciter serrulatis, supra sparse minuteque setosis, subtus subscariosis, minute glanduloso-squamosis, venis lateralibus utrinsecus 12–15, arcuato-adscendentibus, venulis obscuris; floribus solitariis axillaribus, circiter 3 cm. diametro; pedicellis 3–4 cm. longis, glanduloso-setosis; calycis tubo 2–3 mm. longo, extus glabro vel sparse glanduloso-setoso, lobis ovato-lanceolatis, 1.5–1.8 cm. longis, 0.4–0.5 cm. latis, longe caudato-acuminatis, utrinque ad marginem puberulis; petalis albidis subcoriaceis obovatis, circiter 1.8 cm. longis et 1 cm. latis; staminibus numerosis; carpellis numerosis, in capitulo elongato-ovato dispositis; fructibus subglobosis, circiter 1 cm. diametro, drupulis parvis numerosis.

KWANGTUNG: T'sung-hwa District, Sam Kok Shan, Ch'an Woh T'ung Village, *W. T. Tsang 25180* (TYPE), May 1–25, 1935, 2 ft. high, fairly common in swamp, flowers white, fruit yellow.

This species is allied to *Rubus rosaefolius* J. E. Smith, differing in the long-lanceolate and simple-serrulate leaflets and the larger flowers.

THEACEAE

Hartia Dunn

Hartia nitida sp. nov.

Frutex circiter 3 m. altus, ramulis teretibus, junioribus leviter villosis; foliis glabris, coriaceis, oblongo-lanceolatis, 10–13.5 cm. longis, 3.5–5 cm. latis, acuminatis, basi rotundatis, margine remote serrulatis, in sicco olivaceis, utrinque subconcoloribus, supra nitidis, nervis lateralibus utrinsecus 10–14, gracilibus, cum venulis supra subimpressis, subtus subelevatis; petiolo 1.5–1.8 cm. longo, 3 mm. lato, leviter villoso vel subglabro; floribus ignotis; capsulis ovoideis, acuminatis, circiter 1 cm. diametro, 5-valvis; sepalis persistentibus orbicularibus, 5 mm. diametro, rotundatis, extus leviter pubescentibus vel glabris, margine ciliatis; pedicellis 4–6 mm. longis.

KWANGTUNG: Ta-pu District, Tai Mo Shan, *W. T. Tsang 21252* (TYPE), July 21, 1932, a shrub 10 ft. high, abundant on dry steep slopes.

In the small fruits, this species is near *Hartia micrantha* Chun, but it can be distinguished by its relatively long leaves, which are shining above.

Adinandra Jack

Adinandra jubata sp. nov.

Frutex circiter 2.3 m. altus, ramulis novellis dense villosis, indumento ad 6 mm. longo, luteo-brunneo, iridescente; foliis subcoriaceis, lanceolatis, 12–15 cm. longis, 3–4.2 cm. latis, acuminatis, basi late acutis, margine integris, supra glabris, subtus dense villosis, indumento ad 6 mm. longo, luteo-brunneo, iridescente, costa supra impressa, subtus elevata, nervis lateralibus circiter 20, supra subconspicuis vel inconspicuis, subtus in tomento fere occultato, venis tertiariis inconspicuis; petiolo 3–5 mm. longo, villoso; floribus ignotis; fructibus solitariis axillaribus ovoideis, circiter 10 mm. longis et 8 mm. latis, dense longe villosis, stylo persistente, 6–7 mm. longo, inferne villoso, superne glabro, stigmate inconspicuo; sepalis persistentibus ovatis, circiter 10 mm. longis, 6–7 mm. latis, extus dense villosis, intus glabris; pedicellis 6–7 mm. longis, villosis.

KWANGTUNG: Hwei-yang District, Lin Fa Shan, Shek Shing Village, *W. T. Tsang 25601* (TYPE), Aug. 25 or 26, 1935, a shrub 7 ft. high, fairly common, fruits black, edible.

An elegant species with the young branches, lower surfaces of the leaves, and the fruits covered by dense villose iridescent brownish hairs. It is apparently near *Adinandra glischroloma* Hand.-Maz., differing chiefly in the longer and relatively narrower leaves and the much denser and longer hairs. On the lower surfaces of the leaves, the pubescence completely obliterates the venation.

Adinandra nitida Merrill in herb. sp. nov.

Frutex 4 m. altus, omnino glaber, ramulis novellis teretibus purpureo-brunneis; foliis subcoriaceis, ovato-oblongis, 10–12.5 cm. longis, 2.5–5 cm.

latis, acuminatis, basi acutis, margine leviter serrulatis, in sicco supra nitidis, atro-olivaceis, subtus pallidioribus, costa supra leviter elevata, subtus distincte elevata, nervis lateralibus utrinsecus 12–16, utrinque subconspicuis, venis tertiariis inconspicuis; petiolo 1–1.5 cm. longo, supra canaliculato; floribus solitariis axillaribus, 2-bracteatis, bracteis ovatis acutis subcoriaceis, 6–7 mm. longis, 4–5 mm. latis, pedicellis 1.2–1.5 cm. longis; sepalis ovatis acutis, 11–14 mm. longis, 7–8 mm. latis, margine integris; petalis ovatis, 16 mm. longis, 8–10 mm. latis; staminibus circiter 10 mm. longis, filamentis glabris, antheris ciliatis, acuminatis; ovario ovoideo, glabro, 5 mm. longo, stylo glabro, 1–1.4 cm. longo, stigmate 3-fido; fructibus ovoideis, 8 mm. longis, acuminatis, rostratis, sepalis persistentibus.

KWANGTUNG: Hwei-yang District, Lin Fa Shan, Lin Fung Monastery, *W. T. Tsang 25656,* Aug. 11–31, 1935, a shrub 20 ft. high, fairly common in thickets, fruit black, edible. KWANGSI: Shang-sze District, Shih Wan Tai Shan, near Iu Shan Village, *W. T. Tsang 22322* (TYPE), May 18, 1933, a shrub 12 ft. high, abundant in thickets, flowers white, fragrant; same locality, near Hoh Lung Village, *W. T. Tsang 22571,* June 26, 1933, a shrub 10 ft. high, abundant in thickets, fruits black; same locality, near Tang Lung Village, *W. T. Tsang 24431,* Oct. 1–16, 1934, a shrub 7 ft. high, abundant, fruits yellow, edible; Yao Shan, Tseung-yuen, *C. Wang 39413,* June 18, 1936, a small tree along stream, flowers white.

A species allied to *Adinandra acutifolia* Hand.-Maz., differing in the much larger flowers with glabrous petals and ovaries.

THYMELAEACEAE

Wikstroemia Endlicher

Wikstroemia pilosa Cheng, Contr. Biol. Lab. Sci. Soc. China **8**: 140. *f. 6.* 1932; Chun, Sunyatsenia **1**: 276. 1934.

Wikstroemia sericea Domke, Notizbl. Bot. Gart. Berlin **11**: 356. 1932; Chun, Sunyatsenia **4**: 182. 1940; non Christoph. 1931.

Wikstroemia kulingense Domke, Notizbl. Bot. Gart. Berlin **13**: 388. 1936.

Kwangtung, Chekiang, Kiangsi.

Chun (l.c.) adopted *W. sericea* Domke in 1940 instead of *W. pilosa* Cheng, as the former name was nine months earlier, but he overlooked the fact that Domke's specific name was invalidated by Christophersen's species of 1931 from the Cook Islands. Cheng's name is thus the one that should be accepted for the Chinese species, as it in turn is older than *W. kulingense* Domke, 1936.

CORNACEAE

Cornus Linnaeus

Cornus ferruginea Wu, Bot. Jahrb. **71**: 199. 1940.

KWANGTUNG: Hwei-yang District, Lin Fa Shan, Lin Fung Monastery, *W. T. Tsang 25632,* Aug. 11–31, 1935. Originally described from Yao Shan, Kwangsi; new to Kwangtung.

This species falls into the subgenus *Benthamia* Lindl., a group containing species with capitate flowers, for which Hutchinson, Ann. Bot. 6(21): 92. 1942, proposed the generic name *Dendrobenthamia*. He overlooked Wu's species, however.

STYRACACEAE

Styrax Linnaeus

Styrax subcrenata Hand.-Maz. Oesterr. Bot. Zeitschr. 80: 342. 1931.

KWANGSI: Pin-lan, *S. P. Ko 55648,* Aug. 27, 1935, a small tree in woods on slopes; Chuen Yuen, *Z. S. Chung 81981,* June 15, 1937, *82058,* June 19, 1937, a tree in woods along streams. KWANGTUNG: Sin-fung District, Ah Po Kai Shan, Ch'a P'ing Village, *Y. W. Taam 721,* May 1–24, 1938, a small tree 20 ft. high, abundant in thickets. Originally described from Hainan; new to Kwangtung proper and Kwangsi. The leaves of the specimens above cited are in general more distinctly crenate than in the Hainan plants.

SYMPLOCACEAE

Symplocos Jacquin

Symplocos Ernesti Dunn, Jour. Linn. Soc. Bot. 39: 499. 1911; Hand.-Maz. Symb. Sin. 7: 806. 1936; Rehder, Jour. Arnold Arb. 18: 233. 1937.

Symplocos Wilsoni Brand, Repert. Nov. Sp. 3: 216. 1906, non Hemsley.

Symplocos coronigera H. Lév. Repert. Sp. Nov. 10: 431. 1912; Rehder, Jour. Arnold Arb. 18: 233. 1937.

KWANGTUNG: Hop-Po District, *H. Y. Liang 69360,* June 5, 1937, a small tree 5 m. high, in light woods. KWANGSI: Shang-sze District, Shih Wan Tai Shan, Tang Lung Village, *W. T. Tsang 24325,* Sept. 22, 1934, a shrub 5 ft. high, fairly common, flowers white, fragrant. Hupeh, Szechuan, Yunnan, Hunan, Kweichow. New to Kwangtung and Kwangsi.

Symplocos lancilimba Merr. Philip. Jour. Sci. Bot. 23: 259. 1923.

KWANGTUNG: Jen-hwa District, Man Chi Shan, Shek Pik Ha Village, *W. T. Tsang 26351,* May 11–20, 1936, a shrub 5 ft. high, fairly common in thickets in sandy soil; Sin-fung District, Ngok Shing Shan, Sai Lin Shan Village, *Y. W. Taam 410,* March 23–31, 1938, a shrub 8 ft. high, abundant in thickets. Hainan; new to Kwangtung proper.

Symplocos kwangtungensis sp. nov. Subgen. *Hopea,* § *Bobua, Lodhra.*

Arbor parva 6 m. alta, ramulis novellis gracilibus teretibus minute pubescentibus; foliis membranaceis breviter petiolatis oblongo-ovatis, 8–11 cm. longis, 3–3.5 cm. latis, acuminatis, basi late cuneatis vel rotundatis, supra subnitidis glabris costa leviter pubescente excepta, costa nervisque supra impressis, subtus elevatis, nervis lateralibus utrinsecus 5 vel 6 valde arcuato-adscendentibus anastomosantibus, venis tertiariis reticulatis, utrinque subconspicuis; petiolis 2–3 mm. longis, fulvo-pilosis; floribus ignotis; infructescentiis fasciculatis axillaribus sessilibus 5–7-fructigeris, bracteis persistentibus late ovatis, 2 mm. longis, extus minute pubescentibus, fructibus globosis, 6 mm. diametro, 1-locularibus, glabris, lobis calycinis persistentibus oblongis obtusis, 2 mm. longis.

KWANGTUNG: Na Leung River, Shih Wan Tai Shan, *H. Y. Liang 69487* (TYPE), July 8, 1937, a tree 6 m. high, in forests along streams.

This species is close to *Symplocos glandulifera* Brand and *S. yunnanensis* Brand, differing from both in the shorter leaves and the spherical fruits.

Symplocos cordatifolia sp. nov. Subgen. *Hopea,* § *Bobua, Lodhra.*

Frutex circiter 2 m. altus, ramis nigris parce pilosis, ramulis teretibus gracilibus dense brunneo-pilosis; foliis membranaceis vel subchartaceis breviter petiolatis oblongo-ovatis, 5–7 cm. longis, 2–2.5 cm. latis, longe

acuminatis, basi valde cordatis, margine serratis, supra viridibus haud nitidis glabris, subtus pallide viridibus pilosis, nervis lateralibus utrinsecus 5 vel 6 utrinque perspicuis arcuato-anastomosantibus, venis tertiaris reticulatis utrinque distinctis; petiolis 2 mm. longis, dense pilosis; inflorescentiis axillaribus, in ramulis hornotinis orientibus, fasciculatis, fasciculis 3-floris breviter pedunculatis, pedunculis circiter 2 mm. longis, pubescentibus; floribus sessilibus, bracteis late ovatis glabris, 1 mm. longis; calycis tubo crasso, circiter 1 mm. longo, lobis 3 late ovatis glabris, 1 mm. longis; petalis 5 albis oblongis, 3.5 mm. longis, glabris; staminibus circiter 15, filamentis liberis glabris, circiter 4 mm. longis; disco inconspicuo; stylo 5 mm. longo.

KWANGTUNG: Hwei-yang District, Lin Fa Shan, Sam Hang Shek T'an Village, *W. T. Tsang 26027* (TYPE), Oct. 1–19, 1935, a shrub 7 ft. high, fairly common in thickets, flowers white, fragrant.

A distinct species, characterized by its distinctly cordate, somewhat membranaceous leaves, which are pilose beneath, and by the few-flowered, short, fascicled inflorescences and the three sepals.

Symplocos spathulata sp. nov. Subgen. *Hopea,* § *Bobua, Lodhra.*

Arbor parva 4 m. alta, ramulis atro-brunneis glabris; foliis subcoriaceis breviter petiolatis oblongo-obovatis, 6–10 cm. longis, 3–4.5 cm. latis, obtusis vel rotundatis, basi attenuatis, margine integris raro ad apicem pauce denticulatis, utrinque glabris, supra atro-viridibus, subtus pallide viridibus, costa supra impressa, subtus valde elevata, nervis lateralibus utrinsecus circiter 10 utrinque perspicuis prope marginem graciliter anastomosantibus, venis tertiariis reticulatis, utrinque subconspicuis; petiolis crassis glabris, circiter 5 mm. longis; floribus ignotis; infructescentiis axillaribus sessilibus vel breviter pedunculatis, pedunculis ad 8 mm. longis, pubescentibus, bracteis late ovatis, 3 mm. longis, pubescentibus, fructibus singularibus vel pauce fasciculatis sessilibus oblongis, 8 mm. longis, 3 mm. crassis, 1-locularibus, indistincte longitudinaliter striatis, lobis calycinis persistentibus late ovatis, 2.5 mm. longis, glabris.

KWANGTUNG: Hop-Po District, *H. Y. Liang 69359* (TYPE), June 5, 1937, a small tree 4 m. high, in light woods; east of Tung Hing City, *H. Y. Liang 69448,* July 7, 1937, a small tree 4 m. high, in forests.

In the glabrous branches, impressed midrib, and the fascicled, elongated, and slightly grooved fruits, this species is close to *Symplocos congesta* Benth. It can be readily distinguished from the latter in the obovate, almost spatulate, usually round-tipped leaves, and the shorter and smaller fruits, single or sometimes clustered on a short, pubescent peduncle.

VERBENACEAE

Callicarpa Linnaeus

Callicarpa integerrima Champ. var. **serrulata** var. nov.

A typo speciei differt foliis serrulatis.

KWANGTUNG: T'sung-hwa District, Sam Kok Shan, Ch'an Woh T'ung Village, *W. T. Tsang 25228* (TYPE), May 1–25, 1935.

Callicarpa rubella Lindl. var. **Dielsii** (H. Lév.) comb. nov.

Viburnum Dielsii H. Lév. Repert. Sp. Nov. **9**: 443. 1911, Fl. Kouy-Tchéou 66. 1914.

Callicarpa Dielsii P'ei, Mem. Sci. Soc. China **1**(3): 37. 1932; Rehder, Jour. Arnold Arb. **15**: 323. 1934.

Callicarpa rubella Lindl. var. *Hemsleyana* Diels f. *subglabra* P'ei, Mem. Sci. Soc. China 1(3): 41. 1932.

CHEKIANG: Siachu, *R. C. Ching 1760* (isotype of *C. rubella* var. *Hemsleyana* f. *subglabra*), June 3, 1924; no precise locality, *S. Chen 414*, July 2, 1932, *793*, *795*, Sept. 21, 1932. KWEICHOW: Pin-fa, *J. Cavalerie 385* (HOLOTYPE of *Viburnum Dielsii* H. Lév., photo. and merotype in AA), Sept. 4, 1902; Hsufeng, She-loong-san, *S. W. Teng 90440B*, Jan. 20, 1936. KWANGSI: Ch'uan District, Pai-yun-an, *W. T. Tsang 27598*, June 3, 1937; Ling-chuan District, Ta-ling, Yang-wu Village, *W. T. Tsang 27922*, July 21–30, 1937; Yao Shan, Tseung-yuen, *C. Wang 39374*, June 16, 1936; Ping Nan District, *C. Wang 40371*, Nov. 1, 1936. KWANGTUNG: Mei District, Yam Na Shan, *W. T. Tsang 21319*, Aug. 4–31, 1932.

A glabrescent variety of the widely distributed species.

Clerodendron Linnaeus

Clerodendron kwangtungense Hand.-Maz. var. **puberulum** var. nov.

A typo speciei differt foliis utrinque parce puberulis, inflorescentiis dense puberulis.

KWANGTUNG: Yang-shan District, Yang Shan, *T. M. Tsui 785* (TYPE), July-Sept., 1932, a shrub 9 ft. high, fruit bluish.

Clerodendron elachistanthum Merrill in herb. sp. nov.

Frutex circiter 1 m. altus, ramulis brunneis glabris; foliis chartaceis longe petiolatis ovato-cordatis vel ovatis, 12–15 cm. longis, 7.5–10 cm. latis, acuminatis, basi late truncatis vel subcordatis, 5-nerviis, margine integris, supra glabris, subtus minute puberulis, nervis lateralibus (basalibus inclusis) utrinque 4–6, prominulis, rete venularum utrinque prominulo; petiolis 4–6 cm. longis glabrescentibus; inflorescentiis paniculatis terminalibus minute puberulis, circiter 28 cm. longis pedunculis 3 cm. longis inclusis, ramulis primariis oppositis, utrinque 10, inferioribus ad 13 cm. longis, dichotome ramulosis, bracteis linearibus ad 5 mm. longis; floribus minutis, circiter 4 mm. longis, pedicellis 1 mm. longis, bracteolis ad 1 mm. longis; calycibus campanulatis, 2 mm. longis, puberulis, 5-dentatis; corollae tubo 3–4 mm. longo, extus puberulo, 5-lobato, lobis 1–2 mm. longis; staminibus 4, leviter exsertis; stylis 4–5 mm. longis, stigmate 2-lobato, lobis acutis.

KWANGSI: Ch'uan District, Pai-yun-an and vicinity, *W. T. Tsang 27743* (TYPE), June 26, 1937, a shrub 20 ft. high, fairly common in thickets on steep slopes, flowers white, fragrant. KWANGTUNG: Sin-fung District, Hau T'ong Shan, Fuk Lung Monastery, *Y. W. Taam 824*, June 1–19, 1938, a shrub 10 ft. high, fairly common in thickets, flowers light yellow.

This species is apparently near *Clerodendron cyrtophyllum* Turcz., but it is readily distinguished by the much broader leaves, the more elongated panicles, and the very small flowers.

Clerodendron kiangsiense Merrill in herb. sp. nov.

Frutex circiter 2.5 m. altus, ramulis dense brunneo-puberulis, haud lenticellatis; foliis chartaceis longe petiolatis ovato-oblongis, 9.5–12 cm. longis, 5.5–7 cm. latis, acuminatis, basi subtruncatis, margine integris, utrinque parce puberulis, venis lateralibus utrinsecus 4–6, supra subconspicuis, subtus elevatis, rete venularum supra inconspicuo, subtus prominulo; petiolis 2–4.5 cm. longis, puberulis; inflorescentiis cymoso-paniculatis, ad 10 cm. longis, pedunculis 5.5–6 cm. longis, puberulis, bracteis foliaceis oblongis acuminatis, 8–9 mm. longis, 3–4 mm. latis, puberulis, consperse glandulosis;

floribus plus minusve confertis, pedicellis 1–2 mm. longis, bracteolis linearibus, 2–3 mm. longis; calycibus campanulatis, 5–6 mm. longis, puberulis, consperse inconspicue glandulosis, 5-dentatis; corollae tubo 1.2–1.5 cm. longo, haud 1 mm. lato, gracile, superne consperse puberulo, inferne glabro, lobis plerumque oblongis, 5–7 mm. longis, 1.5–3 mm. latis, extus plus minusve puberulis; staminibus circiter 1 cm. exsertis; stylis 1 cm. exsertis, stigmate 2-lobato, lobis acutis.

KIANGSI: Southern Kiangsi, between Kit-than and Sungwu, *J. L. Gressitt 1554* (TYPE), July 1, 1936, a shrub 2.5 m. high, alt. 400 m., flowers white.

This species is near *Clerodendron kwangtungense* Hand.-Maz., differing in the more compactly arranged flowers, in the puberulent and glandular calyces and bracts, and in the absence of lenticels. *Chung 2021* of Pangyung, Chekiang, referred by P'ei (Mem. Sci. Soc. China 1(3): 152. 1932) to *Clerondendron kwangtungense* Hand.-Maz., undoubtedly represents the same species.

RUBIACEAE

Ophiorrhiza Linnaeus

Ophiorrhiza lignosa Merr. Brittonia 4: 176. 1941.

KWANGTUNG: Shih Wan Tai Shan, *H. Y. Liang 69981,* Aug. 5, 1937. KWANGSI: Nan Tanyuan, *C. Wang 40946,* July 3, 1937. Originally described from Upper Burma. New to China.

Dunnia Tutcher

Dunnia sinensis Tutcher, Jour. Linn. Soc. Bot. 37: 69. 1905, Repert. Nov. Sp. 2: 111. 1906; Chun, Sunyatsenia 4: 260. *f. 45. t. 43.* 1940.

KWANGTUNG: Lung-men District, Nan Kwan Shan, Sheung P'ing Village, *W. T. Tsang 25277,* May 29–31, 1935, *25345,* June 1–19, 1935, a shrub 1½–3 ft. high, fairly common in swampy thickets, flowers yellow.

This species has been previously collected only twice, and, including the type collection, only the fruits have been known. The two numbers cited above represent the first flowering specimens collected.

Inflorescences terminal, cymose, about 9–10 cm. long, finely pubescent, the peduncles 6–6.5 cm. long, shortly 4-branched, the pedicels 2–3 mm. long; calyx-tube 1.5 mm. long, minutely 4- or 5-denticulate; petaloid calyx-lobes about 4 in each inflorescence, ovate, about 4.5 × 1.5 cm., acute at both ends, glabrous, 3-nerved, with a stipe about 1 cm. long; corolla-tube campanulate, about 1.2 cm. long and 2 mm. broad, the upper end enlarged, puberulous without, villose within, the lobes 4 or 5, broadly triangular-ovate, about 2 mm. long and 1.5 mm. broad, acuminate; stamens inserted on the upper half of the tube, the anthers 1.5 mm. long, linear-oblong, the filaments about 1 mm. long; styles about 5–6 mm. long, the stigmas 2-fid.

Mussaenda Linnaeus

Mussaenda kwangtungensis sp. nov.

Frutex scandens 1–2.5 m. altus, ramis brunneis, ramulis teretibus brunneis adpresse cinereo-pubescentibus; foliis petiolatis tenuiter chartaceis lanceolato-ellipticis, 7–9 cm. longis, 2–3 cm. latis, longe acuminatis, basi attenuatis, margine integris, utrinque parce pubescentibus vel glabrescentibus, nervis lateralibus utrinsecus 4–6 arcuato-adscendentibus, utrinque con-

spicuis, venis tertiariis utrinque obscuris; petiolis circiter 5 mm. longis, pubescentibus; stipulis linearibus, 1.5–2 mm. longis, dense pubescentibus, caducis; inflorescentiis terminalibus cymosis paucifloris vix ramosis compactis, pedunculis circiter 5 mm. longis, adpresse pubescentibus; floribus subsessilibus; calycis tubo oblongo, 3 mm. longo, pubescente, lobis normalis 5 linearibus, circiter 2.5 mm. longis, dense pubescentibus, lobis petaloideis in unusquisque inflorescentia 2–4 oblongo-ovatis, 3.5–5 cm. longis, 1.5–2.5 cm. latis, apice acutis, basi cuneatis, 5-nerviis, longe stipitatis, stipite 1.5 cm. longo; corollae tubo circiter 4 cm. longo, 1 mm. lato, superne vix ampliato, extus adpresse pubescente, intus superne dense villoso, lobis ovatis acuminatis, 5 mm. longis; staminibus inclusis, antheris 5 mm. longis, stylis brevissimis bilobatis, 3 mm. longis, glabris.

KWANGTUNG: Lung-men District, Nan Kwan Shan, Sheung P'ing Village, *W. T. Tsang 25263,* May 29–31, 1935, a climber 3 ft. high, fairly common in thickets, flowers yellow; Sin-fung District, Hau T'ong Shan, Fuk Lung Monastery, *Y. W. Taam 891* (TYPE), June 1–19, 1938, a semi-woody climber 7 ft. high, fairly common in swamps, flowers yellow.

A species near *Mussaenda divaricata* Hutchinson, but readily distinguished by its smaller, narrower leaves with fewer nerves, and the more slender, much longer corolla-tubes.

Tarenna Gaertner

Tarenna mollissima (Hook. & Arn.) B. L. Robinson, Proc. Am. Acad. 45: 405. 1910; Merr. Philip. Jour. Sci. Bot. 13: 160. 1918; Metcalf, Jour. Arnold Arb. 13: 29. 1932; Rehder, Jour. Arnold Arb. 16: 320. 1935.

Cupia mollissima Hook. & Arn. Bot. Beechey Voy. 192. 1833.

Mussaenda kuliangensis Metcalf, Lingnan Sci. Jour. 11: 527. 1932, syn. nov.

Metcalf, in 1932, reduced *Tarenna incana* Diels and *T. vestita* Diels to the synonymy of *T. mollissima.* In the same year, however, he described a specimen from Fukien as *Mussaenda kuliangensis,* which seems clearly to belong with *Tarenna mollissima.* Fukien specimens in the herbarium of the Arnold Arboretum are: *Chung 2316, 2236, 3731, 3793, 6605, 6687, 8086, Uong Sing Po 12091, Gressitt 1692, J. B. Norton 1474.* The last named specimen is the type of *Mussaenda kuliangensis.*

Randia Linnaeus

Randia Henryi Pritzel, Bot. Jahrb. 29: 581. 1901.

KWANGTUNG: Ho-yuen District, Kwai Shan, Tsing-lo-kong Village, *W. T. Tsang 28692,* April 1 or 2, 1938, a shrub 10 ft. high, fairly common in thickets, flowers whitish yellow, fragrant. KWANGSI: Yao Shan, Ping Nan, *C. Wang 39072,* April 15, 1936, *39125,* May 8, 1936, *39330,* a shrub or small tree, in dense forests, flowers yellowish white; Yao Shan, Tseung-yuen, *C. Wang 39383,* June 16, 1936, a tree 10 m. high, in mixed woods; Hing-on District, Wah Kong, *Z. S. Chung 83663,* Aug. 29, 1937, a tree in woods, fruit young, deep green. Yunnan, Szechuan, Kweichow. New to Kwangsi and Kwangtung.

Gardenia Ellis

Gardenia stenophylla Merr. Philip. Jour. Sci. Bot. 19: 678. 1922.

KWANGTUNG: Shih Wan Tai Shan, *H. Y. Liang 69634,* July 14, 1937, *69969,* Aug. 3, 1937, a shrub 2–3 m. high, in woods along streams, flowers white. KWANGSI: Shang-sze District, Shih Wan Tai Shan, *W. T. Tsang 24115,* Aug. 26, 1934, *23806,* July 11–30,

1934, a woody plant, abundant in swampy thickets, fruit yellow. Hainan. New to continental China.

Geophila D. Don, nomen genericum conservandum propositum

The genus *Geophila* D. Don, Prodr. Fl. Nepal. 136. 1825, consisting of about forty species, is widely distributed in the tropics of both hemispheres. Don's name is antedated by *Geophila* Bergeret, Fl. Bass.-Pyrén. 2: 184. 1803, which is a synonym of *Merendera* Ram. (1798) of the Liliaceae. Under the homonym rule now in effect, *Geophila* D. Don is thus invalidated by *Geophila* Bergeret. Inasmuch as Don's name is well known and about forty species are already ascribed to it, it is proposed that the name *Geophila* D. Don (1825), non Bergeret (1803), be included in the list of *nomina generica conservanda*.

Geophila exigua sp. nov.

Herba 8–10 cm. longa, caulibus prostratis, pubescentibus, nodis radicantibus, internodiis ad 2 cm. longis; foliis oppositis, petiolatis, ovato-orbicularibus, ad 1.5 cm. longis et 1.4 cm. latis, acutis vel subrotundatis, basi truncatis, utrinque sparse setosis, venis lateralibus 3 vel 4, supra inconspicuis, subtus elevatis, venulis obscuris; petiolo 6–12 mm. longo; floribus terminalibus solitariis, pedicellis 4–5 mm. longis, bracteis 1 vel 2, linearibus, 3–6 mm. longis; calycis tubo brevi, 1–1.5 mm. longo, 5-lobato, lobis lanceolatis acuminatis, 2.5 mm. longis; corollae tubo 10–16 mm. longo, 1.5 mm. lato, inferne subglabro, superne villoso, lobis 5, valvatis, oblongo-ovatis, circiter 6.5 × 3.5 mm., margine ciliatis; staminibus 5, inclusis vel exsertis, antheris lineari-oblongis, 1.5–2 mm. longis, filamentis 10–15 mm. longis; ovario 2-locellato, stylis inclusis vel exsertis, 15–20 mm. longis, stigmate 2-lobato, lobis late ovatis.

KWANGTUNG: Tseng-shing District, Nan Kwan Shan, *W. T. Tsang 20330,* April 25, 1932, in shady places, flowers white; Jen-hwa District, Man Chi Shan, Shak Pik Ha Village, *W. T. Tsang 26112* (TYPE), April 1–10, 1936, 4 in. high, fairly common in thickets on steep slopes, flowers white, fragrant.

A species bearing perfect but dimorphic flowers with either exserted stamens and short included styles or included stamens and long exserted styles. It can be distinguished from *Geophila herbacea* (L.) K. Schum. by the much smaller leaves and the much larger flowers.

Paederia Linnaeus

Paederia laxiflora Merrill in herb. sp. nov.

Herbacea vel suffruticosa scandens, circiter 2 m. alta, floribus exceptis glabra vel subglabra, caulibus laevibus glabris 3 mm. diametro, ramulis ultimis teretibus glabris 1 mm. diametro; foliis oppositis lanceolatis, chartaceis vel submembranaceis, plerumque 15–19 cm. longis, 1.5–3 cm. latis, graciliter acuminatis, basi subtruncato-rotundatis, in ramulis junioribus minoribus et basi acutis, utrinque glabris, supra subviridibus, subtus pallidioribus subglaucescentibus, nervis primariis utrinsecus 6, gracilibus distinctis adscendentibus; petiolo 1.5–2 cm. longo, glabro; inflorescentiis axillaribus terminalibusque longe (3–7 cm.) pedunculatis laxe paniculatis glabris vel ramulis ultimis parce pubescentibus laxis; floribus candido-purpureis sessilibus vel breviter pedicellatis; calycibus glabris, 1 mm. longis, in sicco

nigris, dentibus brevissimis; corollae tubo 6–7 mm. longo, extus dense breviter pubescente.

FUKIEN: Lung Chou San, south of Shanghang, *J. L. Gressitt 1663* (TYPE), July 21, 1936, in bamboo forests, alt. 750 m., flowers whitish-lavender.

One of the allies of *Paederia scandens* (Lour.) Merr. (*P. tomentosa* Bl.), but with greatly elongated, very narrow, lanceolate, rather slenderly acuminate leaves, which are abruptly subtruncate-rounded at the base, although the smaller leaves on the branchlets are often acute at the base. Its alliance is clearly with *P. stenophylla* Merr.

Lasianthus Jack

Lasianthus cyanocarpus Jack, Trans. Linn. Soc. 14: 125. 1823.

KWANGTUNG: Foo Lung, Shih Wan Tai Shan, *H. Y. Liang 69758,* July 18, 1937, a shrub 1 m. high, in dense woods, flowers white. Sumatra to Borneo, the Philippines, Indo-China, Formosa, and Hainan. New to Kwangtung.

ARNOLD ARBORETUM,
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PLANTS OF COAHUILA, EASTERN CHIHUAHUA, AND ADJOINING ZACATECAS AND DURANGO, IV[1]

IVAN M. JOHNSTON

SAURURACEAE

Anemopsis californica (Nutt.) H. & A. Bot. Beechey Voy. 390 (1841).

Anemopsis californica var. *subglabra* Kelso, Am. Midl. Nat. 13: 112 (1932).

COAHUILA: Parras, 1880, *Palmer 1184*. CHIHUAHUA: Chihuahua, common plant in swamps, with strong peppery smell, 1908, *Palmer 23;* Meoqui, *LeSueur 45*.

Ranging from California to southern Utah, eastern Colorado, and trans-Pecos Texas, and south to central Mexico. An aromatic herb, spreading by stolons and usually forming large colonies in wet soil. It has been collected in the Rio Grande bottoms in El Paso County, Texas.

SALICACEAE

Salix nigra Marsh. Arbust. Am. 139 (1785).

VERNACULAR NAMES: Sauz; Sauce.

COAHUILA: Hermanas, *Marsh 1599;* Monclova, *Marsh 1712;* Monclova, small tree along Rio Monclova, *White 1731;* Cuatro Cienegas, tree 6 m. tall, *White 1926;* Saltillo, tree becoming more than 30 ft. tall, 1898, *Palmer 27;* mountains 6 mi. east of Saltillo, 1880, *Palmer 1286;* San Antonio de los Alamos, tree 30 ft. tall, *Johnston & Muller 917;* Jimulco, medium-sized tree, Oct. 10, 1905, *Pringle 10086½*. CHIHUAHUA: Chihuahua, river-banks and low wet bottoms, tree 20–30 ft. tall, 1908, *Palmer 41, 42;* Jimenez, tree 3 m. tall, along Rio Florido, *White 2111*.

A widely distributed somewhat variable species ranging from northern Mexico northward to Canada. The material from Coahuila falls into var. *Lindheimerii* Schneider and that from Chihuahua approaches and is perhaps referable to var. *vallicola* Dudley (= *S. Gooddingii* Ball), a western phase of the species, which differs from var. *Lindheimerii* in having usually pubescent, rather than glabrous, fruit and pedicels and lighter, usually yellowish, twigs and branchlets. Schneider, Bot. Gaz. 65: 11 (1918), cites collections of var. *Lindheimerii* from Piedras Negras (*Trelease 133*) and from San Bernardo near the Chihuahua-Durango boundary (*Gregg 479*), and collections of var. *vallicola* from Juarez (*Stearns*) and Santa Eulalia Mts., (*Wilkinson*). On the Texan bank of the Rio Grande forms of the species, perhaps best referred to var. *vallicola,* have been collected from El Paso down to the Big Bend.

The plant is the large arborescent willow most common in our area. Usually associated with *Populus,* it is present along streams and rivers and elsewhere about perennial sources of water.

Salix amygdaloides Anderss. Proc. Am. Acad. 4: 53 (1858).

The type of var. *Wrightii* (Anderss.) Schneider, Bot. Gaz. 65: 14 (1918),

[1]The fifth paper in this series, published out of sequence in Jour. Arnold Arb. 25: 133–182 (April, 1944), included the families Loranthaceae to Nyctaginaceae.

was collected by Charles Wright, no. *1877*, in the bottoms of the Rio Grande, in the general vicinity of old Fort Quitman, Hudspeth Co., Texas. The variety, a trivial and vague one distinguished by narrow leaves, has been collected at various points along the river north into New Mexico. The species probably reaches its southern limit along the Rio Grande in northern Chihuahua.

Salix Thurberi Rowlee, Bull. Torr. Bot. Cl. 27: 252 (1900).

VERNACULAR NAME: Taraiz.

COAHUILA: Monclova, 1939, *Marsh 1650;* San Antonio de los Alamos, arroyo bank, one colony, 6–10 ft. tall, *Johnston & Muller 956;* Jimulco, by stream, Oct. 10, 1905, *Pringle 10086.* CHIHUAHUA: Sierra Encinillas, near Fierro, arroyo bank, shrub 3 m. tall, *Stewart 771;* near Pirámide, tree 12–20 ft. tall, along arroyo, *Johnston 8141;* 3 mi. west of Camargo, slender tree, 6 m. tall, *White 2280.*

Ranging from south-central Texas, the Lower Pecos Valley, and the Rio Grande Valley from the mouth of the river to beyond the Big Bend, and south to northern Nuevo Leon and northeastern Durango. In our area the species is usually recognized by its loose elongate aments of strigose capsules and very slender and elongate distinctly dentate leaves. Some forms of *S. Thurberi* from the Big Bend area of Texas have short, though distinctly dentate, leaves, and when represented by staminate plants may be confused with *S. taxifolia* var. *limitanea.* This variety of *S. taxifolia,* however, usually grows at higher altitudes and has shorter, usually entire leaves, and the sericeous capsules are crowded in short aments not much longer than broad. At some undetermined point along the Rio Grande, but presumably above the mouth of the Rio Conchos, *S. Thurberi* is replaced by *S. exigua.*

Salix exigua Nutt. var. **stenophylla** (Rydb.) Schneider, Bot. Gaz. 65: 25 (1918).

CHIHUAHUA: Banks of the Rio Grande near Juarez, May 4, 1885, *Pringle 220;* Bachimba Canyon, May 30, 1885, *Pringle 23.*

Chihuahua and northeastern Sonora northward through Arizona, New Mexico, and trans-Pecos Texas to Wyoming. In trans-Pecos Texas the species is known from the Davis Mts., and from the Rio Grande bottoms in El Paso and Hudspeth Counties. Readily distinguished from *S. Thurberi* by the form and position of the staminate aments, glabrous or nearly glabrous capsules, and entire leaves.

Salix taxifolia H.B.K. var. **limitanea** var. nov.

A varietate genuina differt foliis maturitate evidenter firmioribus pallidioribus glabrescentibus vel pilis albis gracilioribus rectis valde adpressis sericeo-vestitis.

COAHUILA: Arroyo del Tule, Sierra Hechiceros, bush along arroyo, 10 ft. tall, *Johnston & Muller 1367;* 8 km. northwest of El Tule, Sierra Hechiceros, tree along arroyo, 7 m. tall, *Stewart 533.* CHIHUAHUA: Valley near Chihuahua, Oct. 5, 1885, *Pringle 23½;* Majalca, *LeSueur 162;* Chihuahua, river bank where somewhat shady, not common, upright plant 8–10 ft. tall, 1908, *Palmer 39;* Bachimba Canyon, March 23, 1885, *Pringle 95;* 8 mi. north of San Lucas, road to Chihuahua, *White 2329.* DURANGO: Durango, 1896, *Palmer 473.* SONORA: Between San Pedro and Fronteras, *Hartmann 959;* Arroyo Bavispe, 1940, *Phillips 331.* TEXAS: Limpia Creek, Aug. 22 and 24, 1849, *Wright 669* (TYPE, Gray Herb.); Limpia Canyon, 1902, *Tracy & Earle*

210; Limpia Creek, 15 mi. west of Ft. Davis, 1926, *Palmer 30957;* Little Aguja Canyon, Davis Mts., 1931, *Moore & Steyermark 3125;* eastern Jeff Davis County, 1926, *Palmer 30499;* Cibolo Creek, above Shafter, 1942, *Hinckley 2512.* New Mexico: Animas Valley, Hidalgo Co., 1928, *Wolf 2585.* Arizona: Rucker Canyon, Chiricahua Mts., *Blumer 1623;* Whitewater Creek, Chiricahua Mts., *Blumer 1247;* Palmerlee, Huachuca Mts., *Goodding 4641;* Swissholm Mts., 1884, *Toumey;* Rosemont, Santa Rita Mts., *Toumey 14;* Davidson Canyon, Santa Rita Mts., 1884, *Toumey;* Rillita River, June 22, 1884, *Pringle;* near Tucson, May 7, 1883 and June 23, 1884, *Pringle;* Rincon Mts., 1930, *McKelvey 1579.*

The var. *limitanea* includes most of the material which Schneider, Bot. Gaz. 65: 23 (1918), treated as referable to typical *S. taxifolia,* a species described from cultivated plants collected at Mexico City, Queretaro, and Celaya, in central Mexico. Our present plant ranges from trans-Pecos Texas to southern Arizona and south into northern Mexico. Intermediate forms, connecting it with the phases of *S. taxifolia* found in central, southern, and western Mexico, come from San Luis Potosi, Durango, southwestern Chihuahua, and eastern Sonora. The commonest form of *S. taxifolia* in central Mexico is var. *microphylla* (S. & C.) Schneider, which has short, proportionately broad leaves with evidently toothed margins. The typical form of *S. taxifolia* appears to be only an ecological variant. It is sporadic within the range of var. *microphylla* and is characterized by having larger more elongate obscurely toothed oblanceolate leaves. In general size and shape of leaves this typical form suggests var. *limitanea,* but it differs in having the leaves thinner and less firm in texture and the indument darker, coarser, and less appressed. Northern material representing var. *limitanea* can be quickly distinguished from the southern plants belonging to typical *S. taxifolia* and to var. *microphylla* by its more finely and closely pubescent leaves, lighter color, and generally cleaner and neater appearance. In addition, the thicker leaves tend to be somewhat larger in size, entire-margined, and in age glabrescent. Schneider suggests that the northern plants differ from the southern ones in having a dorsal as well as ventral gland in the staminate flowers. The material I have cited is variable in this respect.

Salix Bonplandiana H.B.K. Nov. Gen. et Sp. **2:** 20 (1817).

Chihuahua: Presa near Chihuahua, 1936, *LeSueur.*

Ranging from Guatemala to central Mexico and north along the western Sierra Madre into southern Arizona and southwestern New Mexico. The northern plants have been referred to var. *Toumeyi* (Britt.) Schneider, Bot. Gaz. 65: 20 (1918), but I have been unable to distinguish them from material collected in central and southern Mexico.

Salix lasiolepis Benth. Pl. Hartw. 335 (1857).

Coahuila: San Lorenzo Canyon, mountains near Saltillo, 7000 ft., April 12, 1906, *Pringle 10210;* mountain canyon (Cañon Iglesia) southeast of Saltillo, Oct. 5, 1905, *Pringle 13708.* Chihuahua: Sacramento Valley, northeast of Chihuahua, March 29 and Oct. 4, 1886, *Pringle 709.*

Ranging from western United States east to Idaho and trans-Pecos Texas and south into northern Mexico. Material from Chihuahua, Sonora, and Texas agrees well with the typical plants of California. The specimens from Coahuila and Nuevo Leon may represent a separable form and

may possibly be the same as *S. Schaffnerii* Schneider from San Luis Potosi.

Salix irrorata Anderss. Öfv. Svensk. Vet. Akad. Förh. **15**: 117 (1858).

This species has been collected on the Texan bank of the Rio Grande opposite Chihuahua, just north of El Paso, by Charles Wright, no. *1873*. It ranges from Arizona to trans-Pecos Texas and north to Colorado. It is closely related to *S. lasiolepis* and appears to differ chiefly in having its stems conspicuously glaucous.

Salix paradoxa H.B.K. Nov. Gen. et Sp. **2**: 20 (1817).

COAHUILA: Cañon del Agua, Sierra Madera, tree to 15 ft. tall, trunk 4 inches diameter with smooth tawny bark, sparse on rock slides about heads of canyons, *Muller 3242*.

The above-cited collection is sterile. It closely resembles fertile material from Cerro Potosi in the Sierra Madre of Nuevo Leon, and, like it, appears referable to *S. paradoxa*. The species is otherwise known from the mountains of central Mexico. The type came from Hidalgo.

Populus arizonica Sargent, Bot. Gaz. **67**: 210 (1919).

Populus mexicana sensu Sargent, Silva **14**: 73. *t. 733* (1902), Man. Trees No. Am. 162. *f. 136* (1905).

VERNACULAR NAMES: Alamo; Alamo cimarron.

COAHUILA: Piedras Negras, 1900, *Sargent;* Sierra del Carmen, Cañon Sentenela, *Wynd & Mueller 527;* Saltillo, June 4, 1888, *Pringle 2098;* Saltillo, *Sargent;* San Antonio de los Alamos, *Johnston & Muller 918*. CHIHUAHUA: Sierra Encinillas, near Fierro, tree 6 m. tall, *Stewart 787;* valley near Chihuahua, March 31, 1886, *Pringle 885* (TYPE of *P. arizonica*); 3 mi. west of Camargo, tree 20 m. tall, *White 2258, 2282;* Jimenez, tree along Rio Florido, 20 m. tall, *White 2112*.

This is the common *Populus* on the intermontane plateau of northern Mexico, growing with *Salix* along rivers and streams in the valleys and frequently cultivated about ranch-houses and in the towns when sufficient soil moisture is available. It ranges north into the Big Bend area of Texas and apparently into the valleys of southeastern Arizona. It grows in the valley of the Rio Grande at least as far west as the mouth of the Rio Conchos. Farther up the river, somewhere between Ojinaga and El Paso, the species is replaced by *P. Wislizeni*.

The species is closely related to *P. Fremontii* and particularly to the various forms of that species found in Arizona. It is characterized by its broad ovate-deltoid leaves, which have a truncate or obtuse and only rarely a slightly cordate base. The earliest leaves and those on vigorous shoots are usually rhombic, long-pointed, and with an acute or narrowly obtuse base. The outer bud-scales are usually densely hairy and the twigs pubescent. The short pedicellate capsules, hairy buds, truncate or obtuse leaf-bases, and the less firm texture of the leaves readily distinguish it from *P. Wislizeni*, and the hairy indument and large obtuse or truncate leaf-blades separate it from *P. Fremontii*.

Sargent published the name "*Populus arizonica*," without accompanying description, as a new name for the plant he had earlier described and illustrated in the Silva as "*P. mexicana* Wesm." For its validity and application, the name *P. arizonica* accordingly rests on the plant which Sargent

had illustrated, described, and discussed as "*Populus mexicana*" in the Silva of North America 14: 73. *t. 733* (1902). A study of this work shows that his illustration and his description apply well to our present Mexican plant and poorly to the slender-stemmed glabrous plant of Arizona which later authors, including Sargent, have accepted as typical *P. arizonica*. The fruiting leafy branch illustrated in Sargent's Silva, and in all editions of his Manual, is drawn from *Pringle 885*, a plant collected near Chihuahua City. The detached large mature leaf portrayed in the Silva is a typical leaf of our Mexican plant. The specimens from which this leaf and the young male aments were drawn can not now be determined. They may have been drawn from Mexican or Arizonan material or a mixture of the two. Sargent cited *Pringle 885*, from Chihuahua, among other Mexican specimens, as representing *P. arizonica* var. *Jonesii* Sargent, Bot. Gaz. 67: 211 (1919). Nevertheless, since the name "*P. arizonica*" was not newly described when published but was based upon "*P. mexicana*" as described and illustrated in the Silva of North America, and since the larger and most distinctive parts of the plate in the Silva of North America are based on Pringle's collections and represent well our present Mexican plant, which is well covered in the accompanying text, I am forced to accept *Pringle 885*, from Chihuahua, as the type of *P. arizonica* Sarg. With the species thus typified the name *P. arizonica* Sarg. is based on very characteristic material of the common *Populus* of our area.

Populus Wislizeni (Wats.) Sargent, Silva No. Am. 14: 71. *t. 732* (1902).

CHIHUAHUA: Banks of the Rio Grande, Juarez, May 31, 1888, *Pringle 1993;* Juarez, 1899, *Rose & Hough 4202*.

Ranging from the Rio Grande Valley, from below El Paso, north through trans-Pecos Texas and New Mexico into southern Colorado. Readily recognized by its very slender and elongate fruiting pedicels and its cordate or reniform, only rarely truncate, leaf-bases.

JUGLANDACEAE

Carya illinoensis (Wang.) K. Koch, Dendr. 1: 593 (1869).

Carya Pecan (Marsh.) Engler & Graebn. Notizbl. Bot. Gart. Berlin, App. 9: 19 (1902).

VERNACULAR NAMES: Nogal liso; Nogal.

Reported as growing wild in northeastern Coahuila along the bottomlands of the Rio San Diego, Rio Rodrigo, and Rio Sabinas, by Pablo Frick, Mexico Forestal 1: 11–14. *fig.* (1923), and by Angel Roldan, Mexico Forestal 3: 30–32. *fig.* (1923). I have been told of pecan-trees which formerly grew about Muzquiz and Nacimiento. I have seen no specimens from Coahuila. However, the species is to be expected in northeastern Coahuila, for pecans have been collected in Val Verde (Devils River) and Uvalde Counties in adjoining Texas. The Arnold Arboretum has several specimens of the species collected near Monterrey, but they have no data indicating whether they were obtained from spontaneous or cultivated trees. The species is widely distributed in central United States and reaches its southern limit in northeastern Mexico.

Juglans microcarpa Berlandier in Berl. & Chovell, Diario Viage Comission de Límites bajo Mier y Teran 276 (1850).

Juglans nana Engelm. Proc. Am. Assoc. Adv. Sci. 5: 226 (1851).

Juglans rupestris Engelm. ex Torr. in Sitgreaves, Rep. Exped. Zuni & Colorado Rivers 171. *t. 15* (1853).

VERNACULAR NAMES: Nogalillo; Nogaillo.

COAHUILA: Hac. Mariposa near Puerto Santa Ana, *Wynd & Mueller 283;* Flores Pasture, Hac. Mariposa, *Marsh 313;* Cañon Bocatoche, becoming 20 ft. tall, *Muller 3120;* 9 mi. north of Hipolito, 10 ft. tall, frequent, *Johnston 7229;* Sierra Encantada, Cañon San Enrique, shrub 4 m. tall, *Stewart 1390;* Sierra del Pino, along arroyos near La Noria, *Johnston & Muller 509;* Sierra Hechiceros, 6 mi. east of El Tule, along dry arroyo, 1–4 m. tall, *Stewart 482;* Sierra Hechiceros, Cañon Indio Felipe, along banks of creek, *Stewart 134a.* CHIHUAHUA: 7½ mi. east of Victoria, bank of arroyo, 12 ft. tall, *Stewart & Johnston 1999.*

A large shrub or low rounded tree, generally less than 15 ft. tall, growing along open arroyos or on dry terraces near watercourses. It reaches its southern limit in our area and extends north into Texas and southeastern New Mexico.

The present species, the dwarf walnut, has generally passed as *J. rupestris.* That species, although attributed to Engelmann, was described and illustrated by Torrey, apparently on the basis of material collected by Bigelow along Devils River, Val Verde Co., Texas. Previous to Torrey's formal description of *Juglans rupestris* Engelm., however, two other binomials had been published for the species. These earlier names, though published without formal descriptions, are accompanied by descriptive comments sufficient to identify them. Since there can be no reasonable doubt as to the application of these early names I have accepted the older, *J. microcarpa* Berl. Berlandier collected *J. microcarpa* on Dec. 7, 1828, in the upper parts of Uvalde Canyon, Texas. He writes concerning it as follows: "A la orilla de los torrentes, y sobre todo, en la del arroyo principal, se encuentran nogales de una especie natural, cuyos frutos muy pequeños, parecidos á una grande avellana, tienen un Endocarpo muy duro, y por esto se ha descrito bajo el nombre de *Juglans Microcarpa.*" Berlandier was a trained botanist. His reference to a wild *Juglans* with a small fruit, the size of a hazelnut, which he found in Uvalde Canyon, is unmistakable. All botanists agree that the small fruit and the dwarf habit of the present species are its obvious distinguishing characters. These are well covered in Engelmann's publication of *J. nana.* In his general discussion of the flora of western parts of Texas, Engelmann writes as follows: "The stately walnut trees of your forests are there reduced to the low *Juglans nana,* a shrub, that bears nuts the size of a musket ball." Since the names *J. microcarpa* and *J. nana* were both published by botanists who mention in their comments diagnostic characters of the species, I believe that the names should compete with *J. rupestris* and that the oldest, *J. microcarpa,* should be taken up as the accepted name of the species.

Juglans major (Torr.) Heller, Muhlenbergia 1: 50 (1900).

Juglans major var. *major* Torr. in Sitgreaves, Rep. Exped. Zuni & Colorado Rivers 171. *t. 16* (1853).

VERNACULAR NAME: Nogal.

CHIHUAHUA: Vicinity of Chihuahua, 1908, *Palmer 141;* 3 mi. west of Camargo, tree 8 m. tall, *White 2284.*

A species ranging from western New Mexico and Arizona south in Chihuahua and Sonora to Durango. It is closely related to the more easterly *J. microcarpa* but is usually separable by its arborescent habit, much larger nuts, and larger, proportionately broader, generally fewer, evidently short-petiolulate leaflets. The bases of the leaflets are strongly oblique, with one side of the blade decurrent on the petiolule for at least a millimeter. The curved more elongate leaflets of *J. microcarpa* are subsessile, with the blade decurrent only very obscurely if at all.

Juglans major var. **Stewartii** var. nov.

A varietate typica differt foliolis 15–21 angustioribus et longioribus 7–12 cm. longis 13–19 mm. latis supra basim latissimis deinde apicem versus gradatim longe attenuatis curvatis.

COAHUILA: Sierra Hechiceros, Cañon Indio Felipe, common along stream in deep watered canyon, tree becoming 45 ft. tall, Sept. 18, 1940, *Johnston & Muller 1358* (TYPE, Gray Herb.); Cañon Indio Felipe, banks of creek, tree 12 m. tall, common, *Stewart 134.*

A plant agreeing with the western *J. major* in its arborescent habit, large fruits, and oblique decurrent leaflet-bases, and resembling *J. microcarpa* in its numerous elongate leaflets.

BETULACEAE

Ostrya virginiana (Mill.) Koch, Dendr. 2^2: 6 (1873).

COAHUILA: Sierra Gloria, July 1939, *Marsh 1878.*

A species of eastern United States that extends south into our area.

FAGACEAE

by CORNELIUS H. MULLER

Quercus Laceyi Small, Bull. Torr. Bot. Cl. 28: 358 (1901).

Quercus breviloba f. *Laceyi* Trel. Mem. Nat. Acad. 20: 102 (1924).

Quercus porphyrogenita Trel. Mem. Nat. Acad. 20: 51. *t. 39* (1924); Muller, Am. Midl. Nat. 18: 844 (1937).

Quercus microlepis Trel. & Muell. in Mueller, Bull. Torr. Bot. Cl. 63: 150 (1936).

Quercus glaucophylla sensu Mueller, Bull. Torr. Bot. Cl. 63: 150 (1936); Jour. Arnold Arb. 17: 162 (1936); non von Seemen (1900).

VERNACULAR NAME: Encino.

COAHUILA: Sierra del Carmen, Cañon Sentenela, *Wynd & Mueller 541, 617;* Rancho Agua Dulce, wooded canyon, east slope of Sierra Manuel, *Wynd & Mueller 345, 346;* Hac. Mariposa, ravine near Puerto Santa Ana, *Wynd & Mueller 230;* Hac. Mariposa, Sierra del Puerto Santa Ana, *Wynd & Mueller 262;* Sorpresa Spring, *Marsh 335, 344;* Palm Canyon, *Marsh 368;* Sierra Gloria, *Marsh 1954, 1978, 2002, 2005;* north slope of Sierra del Oso, Bocatoche, shrub to tree 6–30 ft. tall, common on slopes and arroyo-banks, *Muller 3143;* northwest slopes of Sierra San Lazaro, *Wynd & Mueller 170;* San Lorenzo Canyon near Saltillo, Apr. 12, 1906, *Pringle 10228;* Hillcoat Mesa lying west of Encantada Ranch, July 25, 1938, *Marsh 1426, 1432;* west of Buena Vista Ranch, July 14, 1938, *Marsh 2291;* Cañon Milagro, Sierra Guajes, 12 km. west of Hac. Encantada, tree 6–7 m. tall, *Stewart 1507, 1708;* Cañon San Enrique, Sierra Encantada, 5 km. west of Rancho Buena Vista, tree 5 m. tall, fairly common on hillside at mouth

of canyon, *Stewart 1369;* Sierra del Pino, La Noria, sparse on arroyo-banks, becoming 15 ft. tall, *Johnston & Muller 522;* Sierra del Pino, pine forest north of La Noria, scattered along arroyos, up to 30 ft. tall, *Johnston & Muller 559;* Sierra del Pino, high ridge west of La Noria, north-facing slopes below crest, shrub or tree 6–15 ft. tall, common, *Johnston & Muller 616;* west side of Potrero de la Mula, common on escarpment, 10–15 ft. tall, *Johnston 9207;* Sierra Madera, Cañon Pajarito, abundant small to moderate tree along upper arroyo and on slopes, up to 30 ft. tall, *Muller 3192;* Sierra Madera, Cañon del Agua, abundant in oak-pinyon zone of lower canyon, becoming 20 ft. tall, *Muller 3267;* Sierra Madera, Cañon Charretera, common on flats near La Cueva, tree 20 ft. tall, *Johnston 8933.*

Edwards Plateau region of Texas south in the mountains of Coahuila and the Sierra Madre of Nuevo Leon into Tamaulipas and San Luis Potosi. A well marked but polymorphic species usually most common along waterways in limestone mountains. The white scaly bark, the blue-green cast of its somewhat glaucous and rounded-lobed leaves, and the prominently thickened cup-scales are distinguishing characters. Our plants are obviously conspecific with the Texan *Q. Laceyi.* That species, however, seems closely related to southern Mexican plants comprising *Quercus* series *Glaucoides* Trel. and may possibly be conspecific with one of the older species in that assemblage. Our plant, in fact, has been identified with *Q. glaucophylla* von Seemen, a species first described from Oaxaca. For the present, however, it seems best to maintain the northern plants as distinct and to defer any possible change in their status until the southern species can be given a critical study and their precise relations established.

Quercus oblongifolia Torr. in Sitgreaves, Rep. Exped. Zuni & Colorado Rivers 173 (1853).

VERNACULAR NAME: Encino.

COAHUILA: San Antonio de los Alamos, along creek in canyon, tree 30–50 ft. tall with gray scaly bark, trunk 1–2½ ft. thick, locally common, *Johnston & Muller 863, 865, 866, 867, 869, 870.* CHIHUAHUA: Pirámide, about bouldery rock-masses on gravelly plain, spreading tree 25–30 ft. tall with gray scaly bark, *Johnston & Muller 1425;* 7 mi. south of Pirámide, scattered trees on north slope of grassy hills, *Johnston & Muller 1429.*

Arizona south into Sonora and Chihuahua and with outlying eastern stations in our area. The species is superficially very similar to *Q. Laceyi* and at times the exact differences are difficult to describe. *Quercus oblongifolia,* however, has a decidedly westerly distribution, is usually found on igneous soils, and has leaves differing from those of *Q. Laceyi* in being thicker, grayer, and less prominently veined beneath.

Quercus filiformis Muller, Am. Midl. Nat. 27: 473 (1942).

COAHUILA: Sierra Madera, Cañon Pajarito, sprawling shrub 6–24 inches tall, scattered on rocky arroyo-banks in dense moist pine-oak-maple forest in upper canyon, *Muller 3150* (ISOTYPE).

This species is known only from the type collection. Its procumbent habit, very slender stems, and thin leaf-blades distinguish it from *Q. Pringlei,* the species to which it is probably most closely related. It occurs in densely wooded moist canyons at middle elevations.

Quercus Pringlei von Seemen, Bot. Jahrb. 29: 96 (1900).

VERNACULAR NAME: Encino.

COAHUILA: Mountains near Saltillo, 7000 ft., 1–2 m. tall, Apr. 12, 1906, *Pringle 10199;* mountains near Saltillo, 6500 ft., 2–3 ft. tall, Nov. 6, 1905, *Pringle 13609;* Carneros Pass, limestone hills, Sept. 1, 1889, *Pringle 2382;* Carneros Pass, limestone hills, shrub 2–3 ft. tall, May 10, 1891, *Pringle 3702* (ISOTYPE); arroyo 3 km. southwest of Fraile, *Stanford et al. 344;* Sierra del Pino, common bush along high ridge-crest west of La Noria, 4–7 ft. tall, *Johnston & Muller 600;* Sierra Madera, high crest of main ridge east of Picacho Zozaya, low scrub oak 1–2 ft. tall on rocky open crest, *Johnston 9018;* Sierra Madera, Cañon del Agua, common on steep wooded canyon slopes, shrub becoming 10 ft. tall, *Muller 3206, 3222;* Sierra Mojada, Cañon Hidalgo, open hillsides below crest, fairly common, 7–8 m. tall, *Stewart 1084;* Sierra Mojada, Cañon San Salvador, very abundant in upper canyon, becoming 15 ft. tall, bark scaly and gray, *Muller 3300, 3300a, 3300b;* summit of Picacho Jimulco, *Stanford et al. 91, 111.* ZACATECAS: Valley 15 km. west of Concepcion del Oro, tree 7 ft. tall, *Stanford et al. 551.*

Ranging in western and southern Coahuila and northern Zacatecas, and south in western Nuevo Leon to San Luis Potosi. The species is characterized by its small, usually glabrous leaves with thickish blades and acute apices. The undersurface is at times somewhat glaucous. This plant, usually a small dense bush, occurs in mesic or dry situations at moderate and high elevations.

Quercus sinuata Walt. var. **breviloba** (Torr.) Muller, comb. nov.

Quercus obtusifolia var.? *breviloba* Torr. Bot. Mex. Bound. 206 (1859).

Quercus annulata Buckl. Proc. Acad. Nat. Sci. Phila. **1860**: 445 (1860), non Smith in Rees (1819), non Korthals (1839–42).

Quercus san sabeana Buckl. ex Young, Familiar Lessons in Botany 507 (1873).

Quercus breviloba Sargent, Gard. & Forest **8**: 93 (1895); Muller, Am. Midl. Nat. **18**: 849 (1937).

COAHUILA: Rancho Agua Dulce, lower slopes of Sierra San Manuel, *Wynd & Mueller 308, 309, 311;* Rancho Agua Dulce, wooded canyon on east slope of Sierra San Manuel, *Wynd & Mueller 342, 344;* Sorpresa Spring, *Marsh 336;* Bocatoche, north slope of Sierra del Oso, abundant on slopes, shrub becoming 12 ft. tall, *Muller 3140, 3141.*

Ranging from the Edwards Plateau and from the Big Bend area, Texas, south in the mountains of eastern Coahuila. It has been reported as far south as the vicinity of Monterrey and has been discovered recently in southeastern Presidio County, Texas (Mexican Canyon, just off Fresno Canyon, *Hinckley 2295*), and hence may be expected south of the Rio Grande in northeastern Chihuahua and northwestern Coahuila. Past writers have maintained our plant as specifically distinct from the eastern *Q. sinuata,* but this seems difficult to justify since intermediate forms arise wherever *Q. sinuata* is exposed to xeric conditions or *Q. breviloba* to mesic conditions.

Quercus Greggii (A. DC.) Trel. Contr. U. S. Nat. Herb. **23**: 185 (1922), Mem. Nat. Acad. **20**: 78. *t. 109* (1924).

Quercus reticulata β *Greggii* A. DC. Prodr. 16^2: 34 (1864).

Quercus Loeseneri Trel. Mem. Nat. Acad. **20**: 79. *t. 110* (1924).

VERNACULAR NAME: Encino.

COAHUILA: San Antonio de las Alanzanas, frequent, 30–40 ft. tall, Aug. 31, 1848, *Gregg 380* (ISOTYPE); mountains near Saltillo, 7000 ft., 4–6 ft. tall, Nov. 6, 1905, *Pringle 10120* (isotype of *Q. Loeseneri*); Sierra Madera, Cañon del Agua, shrub up to 12 ft. tall, dominant in chaparral on upper slopes and around peaks, *Muller 3239;*

Sierra Madera, Cañon del Agua, large shrub or tree up to 25 ft. tall, principal constituent of oak forest in moist densely wooded upper canyon, *Muller 3233;* Sierra Madera, Cañon del Agua, shrub or small tree up to 15 ft. tall, with thin gray scaly bark, common in open oak forests on steep canyon slopes, *Muller 3207;* Sierra Madera, common in moist shady coniferous forests on crest of high main ridge east of Picacho Zozaya, shrub 4–8 ft. tall, *Johnston 9022, 9022a.*

Mountains of central and southeastern Coahuila south in the Sierra Madre of Nuevo Leon to San Luis Potosi. A plant of moist canyons and forests in the high mountains.

Quercus Greggii f. **subglabra** Muller, f. nov.

A species recedit foliis subglabratis non revolutis non crassis, venis supra vix impressis.

COAHUILA: Sierra Madera, Cañon del Agua, tree becoming 20 ft. tall, sparse along the moist densely wooded upper arroyos, Sept. 9, 1939, *Muller 3238* (TYPE, Gray Herb.); Sierra Madera, Cañon del Agua, shrub or small tree up to 15 ft., sparse in moist pine oak forest on steep slopes, *Muller 3227, 3227a.*

This form differs conspicuously from typical *Q. Greggii* in having leaves with the lower face devoid of dense fulvous tomentum, the upper face with only weakly impressed veins, and the margins non-revolute. The naming of forms such as this is of doubtful value except when the variant may cause difficulty in delimiting the species. *Quercus Greggii* without its dense tomentum, its revolute leaf-margins, and its veins strongly impressed on the upper leaf-surface presents pronounced differences in aspect, and the relationship of this form to typical *Q. Greggii* might fail to be recognized by those who have not studied it in the field and have only herbarium material before them.

Quercus reticulata Humb. & Bonpl. Pl. Aequin. **2**: 40. *t. 86* (1809).

Quercus durangensis Trel. Mem. Nat. Acad. **20**: 73. *t. 91* (1924).

Quercus diversicolor Trel. Mem. Nat. Acad. **20**: 73. *t. 92–94* (1924); Muller, Am. Midl. Nat. **24**: 708. *fig. 3* (1940).

Quercus rhodophlebia Trel. Mem. Nat. Acad. **20**: 74. *t. 95–97* (1924).

COAHUILA: Sierra del Carmen, Sept. 12, 1936, *Marsh 829;* Sierra del Carmen, Cañon Sentenela, high slopes with northwest exposure, *Wynd & Mueller 634, 636, 641.*

Arizona, New Mexico, and trans-Pecos Texas and south along the Sierra Madre Occidental to central Mexico. Entering our area in northern Coahuila. The several species described by Trelease are obviously only forms of a very polymorphic species which recur throughout the range of the species regardless of geographical location. The typically obovate leaves mucronately toothed about the apex, the very prominent reticulum of the lower leaf-surface, and the long-stalked fruit with loose thin cup-scales very readily distinguish this species from others within our range.

Quercus pungens Liebm. Overs. Danske Vidensk. Forhandl. **1854**: 171 (1854); Muller, Am. Midl. Nat. **24**: 710. *fig. 5* (1940).

Quercus undulata δ Wrightii Engelm. Trans. St. Louis Acad. **3**: 382 (1876).

Quercus undulata var. *pungens* Engelm. Trans. St. Louis Acad. **3**: 392 (1877).

VERNACULAR NAME: Encino.

COAHUILA: Sierra del Carmen, Sept. 2, 1936, *Marsh 870;* Bocatoche, north slope of Sierra del Oso, shrub to 12 ft., sparse on slopes, *Muller 3142;* escarpment on west side of Potrero de la Mula, lower and middle slopes, bush 8–12 ft. tall, *Johnston 9197, 9206;*

high ridge at west end of Sierra Fragua north of Puerto Colorado, a few shrubs about rocks on crest, 5–8 ft. tall, *Johnston 8766;* Puerto Colorado, deep ravines about summit of red sandstone cliffs, shrub becoming 12 ft. tall, *Johnston 8699, 8700;* Sierra del Pino, Dec. 1937, *LeSueur 1501;* Sierra del Pino, Cañon Ybarra, fairly common on arroyo-banks, shrub 2–4 m. tall, *Stewart 1810, 1811, 1812;* Sierra Planchada, Cañon Gringo, banks of dry arroyo in upper canyon, common, shrub 2–6 m. tall, *Stewart 1025, 1030;* Sierra Mojada, Cañon San Salvador, common in middle and upper canyons and arroyos, tree with scaly gray bark, becoming 12 ft. tall, *Muller 3299, 3299a;* west side Valle de Delicias, 3 km. southwest of La Botica, common tree on arroyo-banks, 8 m. tall, *Stewart 2863;* 11 km. northeast of Jimulco, 10–12 ft. tall, *Stanford et al. 64.* CHIHUAHUA: Hills between Alamos Chapado and Alamitos, canyon 18 mi. west of San Carlos, waif tree 6 ft. tall on canyon floor, *Johnston & Muller 26;* Sierra San Carlos, lower part of canyon along road to mines, basally branched shrub 6–12 ft. tall, *Johnston & Muller 50;* Rancho Madera, southeastern base of Sierra Rica, arroyo-banks, common shrub 4 m. tall, *Stewart 2484;* Sierra Almagre, deep moist shaded canyon, up to 30 ft. tall, *Johnston & Muller 1151;* Sierra Almagre, common along arroyos, shrub 6 ft. to tree 20 ft. tall, *Johnston & Muller 1166;* Sierra Diablo, Canyon Rayo, fairly common on arroyo-banks, shrub 4–6 m. tall, *Stewart 955;* Sierra Santa Eulalia, March 27 and Sept. 19, 1885, *Pringle 172, 353;* Sierra Santa Eulalia, El Poza, shrub 1 m. tall, *White 2421.*

Ranging from Arizona and New Mexico through trans-Pecos Texas and south in Chihuahua and Coahuila into Nuevo Leon and Tamaulipas. usually confined to dry limestone slopes and along arroyos at lower elevations in the mountains. The leaves have rough almost sandpaper-like surfaces, imparted by their sparse short stiff pubescence. The species may commonly be recognized by this character alone. Although our plant has been treated as a variety of *Q. undulata,* it is not closely related to that species. *Quercus undulata* is related to *Q. Gambelii. Quercus pungens* is related to neither of these two species. When *Q. undulata* and *Q. pungens* occur on the same mountain ranges, the former is confined to the very highest elevations, while the latter occupies the lower belt of woody vegetation, the two being separated by a belt of several thousand vertical feet in which neither occurs.

A few of the specimens here referred to *Q. pungens* were formerly treated as belonging to *Q. Vaseyana* Buckl. Material from Nuevo Leon (including the type of *Q. sillae* Trel.) belongs to *Q. Vaseyana,* but no collections truly belonging to that species are available from Coahuila or Chihuahua. However, the presence of the species near the Rio Grande, along the lower Pecos and Devils Rivers, and in the limestone country of the western Edwards Plateau, in Texas, makes it almost certain that *Q. Vaseyana* will be found in the similar country in adjoining northern Coahuila. *Quercus Vaseyana* and *Q. pungens* are very closely related and frequently rather difficult to distinguish, the most satisfactory differences being the presence of harsh pubescence on the leaves of *Q. pungens* and its absence on the generally less lobed leaves of *Q. Vaseyana,* cf. Muller, Am. Midl. Nat. 27: 712. *fig. 6* (1940).

Quercus invaginata Trel. Mem. Nat. Acad. 20: 87. *t. 137, 138* (1924).

Quercus invaginata f. *Purpusiana* Trel. Mem. Nat. Acad. 20: 87. *t. 138* (1924).

VERNACULAR NAME: Encino.

COAHUILA: Hillcoat Canyon, west of Buena Vista Ranch, July 13, 1938, *Marsh*

1276; Hillcoat Mesa lying west of Encantada Ranch, July 25, 1938, *Marsh 1419, 1419a, 1420, 1421, 1428;* Sierra Gloria, 1939, *Marsh 1953, 1955, 1974, 1997;* Bocatoche, north slope of Sierra del Oso, shrub or small tree, 2–12 ft. tall, dominant on lower arroyo slopes and in canyons, *Muller 3136, 3137, 3138, 3144;* Sierra San Lazaro, Puerto San Lazaro, abundant in shrub zone on dry slopes, shrub 3–8 ft. tall, usually in clumps of 6–15 trunks up to 2 in. diameter, *Muller 3066, 3067;* San Lazaro, rocky slopes of Puerto San Lazaro, *Wynd & Mueller 138, 139, 162;* Sierra de la Paila, Oct. 1910, *Purpus 5029* (ISOTYPE); Sierra de la Paila, Oct. 1910, *Purpus 5030* (isotype of f. *Purpusiana*); western escarpment of Potrero de la Mula, large shrub 8–12 ft. tall, on middle slopes, *Johnston 9210;* Sierra San Vicente, Cañon Espantosa, about 20 km. southeast of Cuatro Cienegas, *Schroeder 76, 98;* Sierra del Pino, pine forest in middle of sierra north of La Noria. moist shaded arroyos, abundant, up to 30 ft. tall, *Johnston & Muller 560;* Sierra del Pino, vicinity of La Noria, on flats and adjacent open slopes, bush usually 3–6 but frequently 10 ft. tall, abundant, *Johnston & Muller 439, 440, 520, 668, 710;* Sierra del Pino, near mouth of main south canyon, sparse along arroyo, becoming 20 ft. tall, *Johnston & Muller 378;* west base of Picacho del Fuste, along arroyo in small canyon, *Johnston 8457;* tableland north of Cañon del Cuervo Chico, crest of low rounded limestone hill, rare, small tree 15 ft. tall, *Johnston 8550;* Sierra Madera, Cañon Charretera near La Cueva, rocky flat, element in oak chaparral, bush 4–6 ft., *Johnston 8952;* Sierra Madera, Cañon Charretera near La Cueva, rocky flats, tree 20–30 ft. tall, *Johnston 8934;* Sierra Madera, Cañon Charretera, coarse bush in lower canyon, 8–12 ft. tall, *Johnston 9167, 9168;* Sierra Madera, Cañon Pajarito, common in pinyon and shrub zones of lower canyon, shrubs or small trees, 10–20 ft. tall, *Muller 3148, 3149, 3160, 3161;* Sierra Cruces, Cañon Tinaja Blanca, common on north slopes low on canyon side, small tree 10–15 ft. tall, *Johnston & Muller 300, 301, 302, 304;* Cañon La Luz, 3 mi. south of San José, common tree in canyon, *Johnston & Muller 1005, 1006;* San Antonio de los Alamos, along creek in canyon, tree 30–50 ft. tall, trunk 1–2.5 ft. thick, bark gray and scaly, *Johnston & Muller 864, 868, 871, 872.*

Ranging in middle and western Coahuila, frequent at middle altitudes on the mountains and descending along arroyos to the foothills. The acorn-cups in the type material from Sierra de la Paila described by Trelease have loosely inrolled margins, which give them an inflated appearance. Such invaginate excessively inflated cups are common in the species but individual trees of one population, otherwise identical, may have cups variously inflated and some even indistinguishable from those of *Q. grisea.* As a matter of fact the present species is often very difficult to distinguish from *Q. grisea* in northwestern Coahuila, where the two species meet. However, the broad flat dentate leaf-blades of typical *Q. invaginata,* lacking the dense tomentum of *Q. grisea,* make the separation of the two species obligatory, especially since the similarities between them do not arise from any close genetic relationship.

Quercus intricata Trel. in Standl. Contr. U. S. Nat. Herb. **23**: 185 (1922), Mem. Nat. Acad. **20**: 84. *t. 126–128* (1924); Muller, Am. Midl. Nat. **24**: 710. *fig. 4* (1940).

Quercus microphylla β crispata A. DC. Prodr. 16²: 36 (1864).

Quercus intricata f. *ovata* Trel. Mem. Nat. Acad. **20**: 85. *t. 128* (1924).

Quercus intricata f. *erratica* Trel. Mem. Nat. Acad. **20**: 85. *t. 128* (1924).

VERNACULAR NAMES: Encino; Charasquilla.

COAHUILA: Puerto San Lazaro, abundant on open slopes of Sierra San Lazaro, shrub 1–4 ft. tall, *Muller 3085;* Puerto San Lazaro, Sierra San Lazaro, sparsely scattered in the shrub zone, shrub to 2 ft. tall, much branched at base, *Muller 3065;* San Lazaro, rocky slopes of Puerto San Lazaro, *Wynd & Mueller 163;* Buena Vista, south of Saltillo, shrub-oak 2–5 ft. tall, abundant, July 24, 1848, *Gregg 296* (ISOTYPE of *Q. microphylla β crispata* and *Q. intricata*); San Lorenzo Canyon, southeast of Saltillo,

canyon-sides, forming thick crowded clumps 3–5 ft. tall, 1904, *Palmer 431;* San Lorenzo Canyon, southeast of Saltillo, 1905, *Palmer 552, 553, 554, 555, 556, 557, 745, 746* (isotype of f. *ovata*), *747, 748, 751;* Carneros Pass, limestone hills, 2–3 ft. tall, May 10, 1891, *Pringle 3701;* Carneros Pass, 2 ft. high, Sept. 10, 1889, *Pringle 2862;* Sierra del Pino, 1937, *LeSueur 1502;* Sierra del Pino, Cañon Ybarra, fairly common on arroyo-banks, shrub 3 m. tall, *Stewart 1861;* Sierra del Pino, high western ridge near old log-slide, forming chaparral along rocky arid crest, 1–3 ft. tall, *Johnston & Muller 565;* Sierra del Pino, pine forests north of La Noria, abundant as scrub in open conifer forest, clumps 4 ft. tall, *Johnston & Muller 561;* Sierra del Pino, high ridge west of La Noria, abundant along crest and on adjacent slopes, *Johnston & Muller 610;* Sierra del Pino, vicinity of La Noria, clumps 2–4 ft. tall, *Johnston & Muller 441, 442, 443, 444, 445;* tableland north of Cañon del Cuervo Chico, forming thickets 3–6 ft. tall on low rounded limestone hills, *Johnston 8551;* Sierra Madera, scrub oak on high rocky open crest of main ridge east of Picacho Zozaya, 1–2 ft. tall, common, *Johnston 9018a;* Sierra Madera, Cañon Charretera near La Cueva, low bush 2–4 ft. tall on rocky flats, *Johnston 8951;* Sierra Madera, Cañon Pajarito, abundant on dry open slopes in upper arroyo, shrub 1–4 ft. tall, *Muller 3191;* Sierra Fragua, thickets 2–5 ft. tall with pines on eastern slopes of high ridge north of Puerto Colorado, *Johnston 8779;* Sierra Cruces, Cañon Tinaja Blanca, common on north slopes low down on canyon-side, shrub to 3 ft. tall, *Johnston & Muller 299, 303;* Sierra Cruces, foothills 3 mi. southeast of Santa Elena, sparse on arroyo-banks, 3 ft. tall, *Johnston & Muller 1260;* Sierra Mojada, Cañon San Salvador, crests, dominant shrub becoming 5 ft. tall, *Muller 3310;* Sierra de Parras, Apr. 1905, *Purpus 1137;* Sierra de Parras, *Shreve & Tinkham 9876, 9888;* Sierras Negras, south of Parras, tree 8–10 ft., *Stanford et al. 147*. CHIHUAHUA: Sierra Almagre, sparse in open rocky arroyo, becoming 5 ft. tall, *Johnston & Muller 1182;* Sierra Diablo, common about margins of meadows high on northwest end of sierra, 1–2 m. tall, *Stewart 961*. ZACATECAS: Cedros, 1908, *Lloyd 130*.

Ranging from trans-Pecos Texas (Davis and Chisos Mts.) south in Coahuila and adjacent Chihuahua and Zacatecas into Nuevo Leon. A xeric species characteristic of sunny slopes and flats and exposed dry ridges. It is commonly associated with *Q. invaginata* in central Coahuila and is one of the characteristic species in the Coahuilan oak-chaparral. The small revolute leaves with a dense buff tomentum beneath and the low habit of growth distinguish it.

Quercus arizonica Sargent, Gard. & Forest 8: 92 (1895).
Quercus Sacame Trel. Mem. Nat. Acad. 20: 89. *t. 142* (1924).
Quercus endemica Muller, Am. Midl. Nat. 18: 846 (1937).

VERNACULAR NAME: Encino.

COAHUILA: Sierra del Carmen, Cañon Sentenela, *Wynd & Mueller 540, 565, 638* (isotype of *Q. endemica*); Sierra Cruces, Cañon Encinal, 8 km. southwest of Santa Elena, frequent in shady canyon, deciduous tree becoming 12 m. tall, trunk 75 cm. thick, *Stewart 2273, 2274;* 10 km. southwest of Santa Elena, side of canyon, tree 8 m. tall, trunk 5 dm. thick, *Stewart 1148*. CHIHUAHUA: Sierra Organos, canyon west of Organos, large live oak, tree said to be only one of kind in region, *Stewart & Johnston 2078*. TEXAS: Chisos Mts., Boot Spring, *Mueller 7936* (distributed as *Q. reticulata*).

Ranging from Arizona south in the highland of eastern Sonora and western Chihuahua into Durango and extending eastward in scattered stations into trans-Pecos Texas and Coahuila. The material from our area comes from the ragged eastern edges of the range of *Q. arizonica* where it is a rare relict, and its characters are so masked by aberrations characteristic of such edge-of-the-range individuals that the identity of some specimens has not been immediately evident. Though some plants from the Chisos Mts.,

formerly referred to *Q. endemica,* cf. Muller, Am. Midl. Nat. 24: 706 (1940), are probably best referred to *Q. grisea,* the Chisos specimen cited above, however, seems clearly to belong to *Q. arizonica. Quercus arizonica* is characterized by oblong to oblanceolate leaves with the reticulum very prominent beneath. It is distinguished from *Q. reticulata* by its more narrow leaves, its shorter fruiting peduncles, its thickened and tightly appressed cup-scales, and its occurrence at much lower and drier levels.

Quercus cordifolia Trel. Mem. Nat. Acad. 20: 84. *t. 125* (1924).

Quercus striatula Trel. Mem. Nat. Acad. 20: 93. *t. 151* (1924).

Quercus striatula f. *otinapensis* Trel. Mem. Nat. Acad. 20: 94. *t. 152* (1924).

COAHUILA: Carneros Pass area, small tree 20 ft. tall, trunk up to 1 ft. thick, July 1880, *Palmer 1278* (GH, ISOTYPE); Carneros Pass area, 1880, *Palmer 1178* (AA).

Ranges from southern Coahuila into Durango, Zacatecas, and Nuevo Leon. Apparently most abundant in Nuevo Leon. This species is very polymorphic as to leaf-size and -shape and as to habit. It varies from a small tree with moderate-sized leaves, very similar to *Q. grisea,* to a diminutive shrub (3–6 ft. tall) with tiny leaves. Although *Q. cordifolia* is very similar to *Q. grisea* in one of its forms, it is by no means conspecific with that species. Unfortunately the type and other collections from the type locality are all of the large-leaved form. This form, however, is not separable from the diminutive form, there being many intermediates. *Quercus cordifolia* occurs at medium and high altitudes in the larger mountain masses and does not extend down into the shrub and small tree zones as does *Q. grisea* so commonly further north.

Quercus grisea Liebm. Overs. Danske Vidensk. Forhandl. 1854: 171 (1854); Muller, Am. Midl. Nat. 24: 706. *fig. 1* (1940).

Quercus undulata var. *grisea* Engelm. Trans. St. Louis Acad. 3: 393 (1877).

Quercus santaclarensis Muller, Am. Midl. Nat. 19: 583 (1938).

VERNACULAR NAME: Encino.

COAHUILA: Sierra del Carmen, Sept. 6–12, 1936, *Marsh 832, 854;* western slopes of Sierra del Carmen, 8 km. northeast of Hac. Encantada, fairly common on hillsides, tree 5–6 m. tall, *Stewart 1552;* Sierra del Pino, abundant in dense pine forests in middle sections of sierra north of La Noria, tree 45 ft. tall, *Johnston & Muller 572;* Sierra del Pino, La Noria, common along arroyo, becoming 20 ft. tall, *Johnston & Muller 521;* Sierra Hechiceros, Cañon Indio Felipe, spreading tree, becoming 25–30 ft. tall, *Johnston & Muller 1341, 1342;* Sierra Hechiceros, Cañon Indio Felipe, along creek and on hillsides, becoming 15 m. tall, *Stewart 167, 182;* Sierra Hechiceros, Cañon Madera, canyon-bottoms and flats, becoming spreading tree 25–30 ft. tall, *Johnston & Muller 1284, 1285, 1289, 1293;* foothills of Sierra Cruces, along arroyo 2 mi. east of Santa Elena, clumps 10 ft. tall, *Johnston & Muller 798;* Sierra Cruces foothills, Boquilla east of Santa Elena, small colony along arroyo-bank, shrub 3–4 m. tall, *Stewart 2269.* CHIHUAHUA: Sierra Rica, Cañon Madera, open slopes and arroyo-banks, abundant tree 5 m. tall, trunk 4 dm. thick, *Stewart 2463, 2548;* 1½ mi. west of Tepopote, tree along arroyo, 35 ft. tall, *Johnston & Muller 1397;* 1 mi. west of San Salvador, large trees along arroyo, becoming 35 ft. tall, trunk 18 inches thick, *Johnston & Muller 1398, 1399;* about bouldery hills on gravelly plain west of Pirámide, common tree 25–30 ft. tall, *Johnston & Muller 1422, 1423, 1424;* 7 mi. south of Pirámide, tree on north slope of grassy hills, 20–25 ft. tall, *Johnston & Muller 1428, 1429;* canyon north of Mesteñas, broad spreading tree 20–25 ft. tall, common on flats and slopes, *Johnston 7955.*

Ranging from Arizona east to trans-Pecos Texas and south into northern

Mexico. Characterized by a combination of furrowed gray bark, dingy gray pubescent leaf-blades oblong to ovate in outline, and usually short-stalked fruit. In eastern Coahuila at times difficult to distinguish from *Q. Mohriana*. Frequently distinguished with difficulty from *Q. invaginata* and *Q. subcordata* of eastern Coahuila and of central and southern Coahuila.

Quercus chihuahuensis Trel. Mem. Nat. Acad. 20: 85. *t. 129, 130* (1924).

Quercus undata Trel. Mem. Nat. Acad. 20: 86. *t. 135* (1924).

VERNACULAR NAME: Encino.

CHIHUAHUA: Sierra Organos, large live-oak, 5 m. tall, common on slopes and along arroyos near Organos, *Stewart & Johnston 2068;* rocky hills near Chihuahua, May 8 and Oct., 1885, *Pringle 74, 355* (ISOTYPE).

Ranging along the Sierra Madre in Chihuahua and Sonora south to Durango and Sinaloa and extending eastward into our area. Trelease, l. c., reports a collection (*Pringle 970*) from the Mapula Mts. The species is characterized by its dense covering of long buff-colored pubescence on leaves and twigs. It is rather closely related to *Q. grisea* but is readily distinguished by its soft almost felt-like indument.

Quercus Mohriana Buckl. ex Rydb. Bull. N. Y. Bot. Gard. 2: 219. *t. 31* (1901), exclusive of Mexican specimens cited, which are *Q. intricata* Trel.

VERNACULAR NAME: Encino.

COAHUILA: Rancho Agua Dulce, lower slopes of Sierra San Manuel, *Wynd & Mueller 306, 307;* Santo Domingo, open slope of igneous hill, *Wynd & Mueller 483;* Santo Domingo, limestone hill, *Wynd & Mueller 451;* Palm Canyon, *Marsh 373;* ravines near Puerto Santa Ana, *Wynd & Mueller 232, 233;* Hillcoat Mesa lying west of Encantada Ranch, July 25, 1938, *Marsh 1427, 1431;* Hillcoat Canyon, west of Buena Vista Ranch, July 13, 1938, *Marsh 1295, 1296;* high mesa in the Sierra Encantada about 16 km. northwest of Rancho Buena Vista, common on rocky hillside, shrub 15 dm. tall, *Stewart 1442;* Valle de los Guajes, 10 km. south of Rancho Buena Vista, common on grassy hillside, shrub 2–3 m. tall, *Stewart 1357;* El Berrendo, shrub or small tree, *White 1798, 1858.*

Ranging in Texas from the western Edwards Plateau and The Breaks of the Plains west to the Glass Mts. and south in the trans-Pecos area into northeastern Coahuila. It is characterized by having its oblong leaves rather dark green above and creamy white with dense tomentum beneath, cf. Muller, Am. Midl. Nat. 24: 708. *fig. 2* (1940). In Coahuila a variety of shade forms are confusing because of their expanded leaves with light tomentum, but even in these the dual coloration is constant, as are also the more fundamental characters of the species.

Quercus undulata Torr. Ann. Lyceum N. Y. 2: 248. *t. 4* (1828).

Quercus Fendleri Liebm. Overs. Danske Vidensk. Forhandl. 1854: 170 (1854).

Quercus undulata γ pedunculata A. DC. Prodr. 16^2: 23 (1864).

Quercus undulata β obtusifolia A. DC. Prodr. 16^2: 23 (1864).

Quercus venustula Greene, Ill. West Amer. Oaks 69. *t. 32* (1890).

Quercus obtusifolia Rydb. Bull. N. Y. Bot. Gard. 2: 213. *t. 29* (1901), non Don (1825).

Quercus Rydbergiana Cockerell, Torreya 3: 7 (1903).

Quercus undulata Rydbergiana Cockerell, Torreya 3: 86 (1903).

Quercus confusa Woot. & Standl. Contr. U. S. Nat. Herb. 16: 116 (1913).

Quercus media Woot. & Standl. Contr. U. S. Nat. Herb. 16: 116 (1913).

Quercus subobtusifolia A. Camus, Bull. Soc. Bot. France **81**: 816 (1934).
Quercus carmenensis Muller, Am. Midl. Nat. **18**: 847 (1937).

COAHUILA: Sierra del Carmen, Cañon Sentenela, high slopes with northwest exposure, *Wynd & Mueller 633, 635, 639* (isotype of *Q. carmenensis*).

Ranging from Arizona and Colorado through New Mexico and trans-Pecos Texas into northern Coahuila. There is a possibility that eventually it may be found in the higher mountains of Chihuahua. The species has been variously interpreted and has been one of the most problematic in the southwestern United States and adjacent Mexico. The type collection resembles a form of *Q. grisea* and even looks a bit like *Q. pungens*. Growing in the same locality and radiating out over the entire range of the species are a dozen or more forms of it, some of which have been described as distinct species. The fact that the type collection came from a form of the species characteristic of xeric sites at lower elevations has caused it to be confused with *Q. grisea* and *Q. pungens* and has obscured its true relationships with *Q. Gambelii*. A study of many populations of this variable species in the field (including the type locality) has shown clearly that the form illustrated as *Q. venustula* by Greene is the most common form. It represents a form morphologically about midway between *Q. Gambelii* and the type of *Q. undulata*. *Quercus obtusifolia* is a form of *Q. undulata* even nearer to *Q. Gambelii* than *Q. venustula*. *Quercus carmenensis*, on the other hand, is an even more extreme variant in another direction. A thoroughly conservative treatment permits the recognition of both *Q. Gambelii* and *Q. undulata*, for the two assemblages involved show definite genetic differences; they often occur intermingled in the same habitat without intermediate forms. The narrow shallowly lobed leaves and obligate shrub-habit of *Q. undulata* and its tendency to frequent open drier and lower sites readily distinguish it from the arboreal (sometimes shrubby) *Q. Gambelii*, with its broad deeply lobed leaves.

Quercus Gambelii Nutt. Jour. Acad. Nat. Sci. Phila. n. s. **1**: 179 (1848).
Quercus alba β? Gunnisonii Torr. Pac. R. R. Rep. 2^1: 130 (1855).
Quercus stellata δ Utahensis A. DC. Prodr. 16^2: 22 (1864).
Quercus Douglasii β Gambelii A. DC. Prodr. 16^2: 23 (1864).
Quercus Douglasii γ Novomexicana A. DC. Prodr. 16^2: 24 (1864).
Quercus undulata var. *Gambelii* Engelm. Trans. St. Louis Acad. 3: 382, 392 (1876–77).
Quercus utahensis Rydb. Bull. N. Y. Bot. Gard. **2**: 202. *t. 25* (1901).
Quercus submollis Rydb. Bull. N. Y. Bot. Gard. **2**: 202. *t. 25* (1901).
Quercus Vreelandii Rydb. Bull. N. Y. Bot. Gard. **2**: 204. *t. 26* (1901).
Quercus leptophylla Rydb. Bull. N. Y. Bot. Gard. **2**: 205. *t. 26* (1901).
Quercus Gunnisonii Rydb. Bull. N. Y. Bot. Gard. **2**: 206. *t. 25* (1901).
Quercus nitescens Rydb. Bull. N. Y. Bot. Gard. **2**: 207. *t. 27* (1901).
Quercus novomexicana Rydb. Bull. N. Y. Bot. Gard. **2**: 208. *t. 27* (1901).
Quercus Eastwoodiae Rydb. Bull. N. Y. Bot. Gard. **2**: 210. *t. 28* (1901).
Quercus pauciloba Rydb. Bull. N. Y. Bot. Gard. **2**: 215. *t. 30* (1901).
Quercus utahensis var. *submollis* Sargent, Bot. Gaz. **65**: 442 (1918).
Quercus Marshii Muller, Am. Midl. Nat. **18**: 848 (1937).

COAHUILA: Sierra del Carmen, Sept. 12, 1933, *Marsh 823;* Sierra del Carmen, Cañon Sentenela, high slope with northwest exposure, *Wynd & Mueller 640* (isotype of *Q. Marshii*).

Ranging from South Dakota to Nevada and south into Coahuila and Chihuahua. A species fully as polymorphic as *Q. undulata,* as its list of synonyms attests. Nomenclatorial recognition for the various forms of *Q. Gambelii* seems impractical, for they occur haphazardly throughout the range of the species and are always connected by intermediates. In the southern part of its range *Q. Gambelii* is confined to very high mesic elevations, being particularly common about talus slopes.

Quercus Muehlenbergii Engelm. Trans. St. Louis Acad. 3: 391 (1877).

Quercus Prinus (*acuminata*) Michx. Hist. Chênes Amer. Sept. (20). *t. 8* (1801).

Quercus castanea Mühl., Neue Schr. Ges. Naturf. Fr. Berlin 3: 396 (1801), non Nees (1801, earlier in the year).

Quercus castanea var. *macrophylla* Hampton, Report Ohio State For. Bur. 1: 195 (1886).

Quercus acuminata Sargent, Gard. & Forest 8: 93 (1895).

Quercus Brayi Small, Bull. Torr. Bot. Cl. 28: 558 (1901); Muller, Am. Midl. Nat. 24: 714. *fig. 8* (1940).

Quercus Muehlenbergii var. *Brayi* Sargent, Bot. Gaz. 65: 442 (1918).

Quercus sentenelensis Muller, Am. Midl. Nat. 18: 849 (1937).

Coahuila: Sierra del Carmen, Cañon Sentenela, *Wynd & Mueller 629* (isotype of *Q. sentenelensis*); Rancho Agua Dulce, wooded canyon on east slope of Sierra San Manuel, *Wynd & Mueller 347;* Sierra Gloria, *Marsh 1905.*

Ranging from the Atlantic region of the United States through central and western Texas (locally) and south in eastern Coahuila into Nuevo Leon. The differences between *Q. sentenelensis* and other forms of *Q. Muehlenbergii* have not proved constant. In fact, any division of the species seems doomed to failure, even though wide differences exist within the species as here accepted. These differences, however, are poorly if at all correlated with geography and with one another. *Quercus Muehlenbergii* is the only member of the series *Prinoides* (Chestnut Oaks) in our range, and its distinction from other species by its evenly repand-toothed leaves, broadly lanceolate to obovate in outline, is readily evident. In our range it is confined to moist stream banks in mesic mountains.

Quercus fusiformis Small, Bull. Torr. Bot. Cl. 28: 357 (1901); Muller, Am. Midl. Nat. 24: 718. *fig. 10* (1940).

Quercus virginiana var. *fusiformis* Sargent, Bot. Gaz. 65: 448 (1918).

Coahuila: Highway between Muzquiz and Hac. Mariposa, *Wynd & Mueller 285;* Santa Anna Canyon, *Marsh 518;* Monclova, 1880, *Palmer 1274;* Saltillo, single clump, base of hill, 6–8 ft. tall, 1898, *Palmer 299.*

Edwards Plateau, Texas, south into eastern Coahuila, northern Tamaulipas, and Nuevo Leon. In southern Tamaulipas and Nuevo Leon *Q. fusiformis* gives way to *Q. oleoides* without intermediates. On the eastern escarpments of the Edwards Plateau, in Texas, some intermediates occur connecting *Q. fusiformis* and *Q. virginiana* Mill. This transition between *Q. fusiformis* and *Q. virginiana* is not so pronounced and so complete as between *Q. sinuata* var. *breviloba* and *Q. sinuata* and a comparable reduction of *Q. fusiformis* to varietal rank under *Q. virginiana* does not seem to be required. The species occurs on dry limestone slopes and flats and along streams.

Quercus Emoryi Torr. in Emory, Notes Mil. Reconn. 151. *t. 9* (1848); Muller, Am. Midl. Nat. 24: 718. *fig. 11* (1940).

Quercus hastata Liebm. Overs. Danske Vidensk. Forhandl. 1854: 171 (1854).

Quercus Duraznillo Trel. Mem. Nat. Acad. 20: 122. *t. 220, 221* (1924).

Quercus balsequillana Trel. Mem. Nat. Acad. 20: 123. *t. 220* (1924).

Ranging from Arizona east to trans-Pecos Texas and south along the Sierra Madre in Chihuahua and Sonora. Trelease, Mem. Nat. Acad. 20: 121 (1924), reports the species from the "vicinity of Chihuahua (*Palmer 359*)." The apparent absence of this species in Coahuila and eastern Chihuahua is puzzling, for it is abundant in the Chisos Mts. in adjacent Texas, and its common associates in the Chisos, *Q. grisea* and *Q. pungens*, range well south into our area. The small commonly hastate leaves of this species, usually glabrous except for tufts of hair on the lower surface of the blade along the base of the midrib, and its small annual fruits adequately distinguish *Q. Emoryi* from other species of the subgenus *Erythrobalanus* in our area. It is most commonly found on grassy igneous slopes and along waterways in igneous mountains at low elevations.

Quercus saltillensis Trel. Mem. Nat. Acad. 20: 183. *t. 368, 369* (1924).

Quercus carnerosana Trel. Mem. Nat. Acad. 20: 183. *t. 369* (1924).

COAHUILA: San Lorenzo Canyon near Saltillo, April 12, 1906, *Pringle 10229;* Carneros Pass area, up to 30–40 ft. tall, March 1880, *Palmer 1277* (TYPE); Carneros Pass, mountains, Sept. 15, 1889, *Pringle 2802* (isotype of *Q. carnerosana*); Sierra Negras, south of Parras, *Stanford et al. 145.*

Ranging in southern Coahuila and in the Sierra Madre of Nuevo Leon. This shrub is characterized by its annual fruition and by small lanceolate leaves, usually glabrous and entire, or sparsely pubescent beneath and toothed. It is commonly encountered on dry limestone slopes at moderate elevations.

Quercus hypoleucoides A. Camus, Bull. Mus. Hist. Nat. II. 4: 124 (1932); Muller, Am. Midl. Nat. 24: 721. *fig. 13* (1940).

Quercus confertifolia Torr. Bot. Mex. Bound. 207 (1840), non Humb. & Bonpl. (1809).

Quercus hypoleuca Engelm. Trans. St. Louis Acad. 3: 384 (1876), non Miquel (1855).

COAHUILA: Sierra del Carmen, Sept. 12, 1936, *Marsh 831;* Sierra del Carmen, Cañon Sentenela, *Wynd & Mueller 533, 564, 637.* CHIHUAHUA: Peña Fea near Chihuahua, *LeSueur 530.*

Ranging from trans-Pecos Texas to Arizona and south into northern Coahuila and along the Sierra Madre in Chihuahua and Sonora. The characteristically narrowly lanceolate leaves, dark green above and densely white-tomentose beneath, distinguish this species. It occurs on moist slopes and along waterways at high elevations.

Quercus hypoxantha Trel. Mem. Nat. Acad. 20: 170. *t. 339* (1924).

Quercus errans f. *graciliramis* Mueller, Jour. Arnold Arb. 17: 169 (1936).

VERNACULAR NAME: Encino.

COAHUILA: Mountains near Saltillo, small tree, 7000 ft. alt., Apr. 12, 1906, *Pringle 10227* (TYPE); 26 km. northwest of Fraile, top of mountain with *Abies, Pseudotsuga* and *Pinus, Stanford et al. 440;* Sierra del Pino, middle of sierra about 10 mi. north of La Noria, scattered in open pine forests and in chaparral on adjacent slopes below ridge-crest, several erect or ascending stems, 4–8 ft. tall, *Johnston & Muller 566, 567;*

Sierra Madera, Cañon del Agua, tree common in moist upper canyons, up to 25 ft. tall, trunk to 10 inches thick, *Muller 3232;* Sierra Madera, Cañon del Agua, shrub or small tree with hard black checkered bark on branches, abundant in dense oak chaparral on steep slopes at 8000 ft., up to 20 ft. tall, trunks becoming 3 in. thick, *Muller 3213;* Sierra Madera, Cañon del Agua, shrub or small tree, to 20 ft. tall, trunk 3 in. thick, dense pine-oak forest, *Muller 3214;* Sierra Madera, high crest of main ridge east of Picacho Zozaya, open forests, common, shrub 5–8 ft. tall, *Johnston 9021;* Sierra Madera, Cañon Charretera, lower parts of conifer-forests, tree or shrub 8–10 ft. tall, *Johnston 9054.* CHIHUAHUA: Sierra Diablo, 12–14 km. up Cañon Rayo, common on banks of dry arroyo, shrub 5–8 m., *Stewart 921, 921a, 924;* 15 km. up Cañon Rayo, Sierra Diablo, common tree on dry hillside, 10 m. tall, *Stewart 931.*

Ranging from southeastern Chihuahua eastward in the higher mountains of central and southern Coahuila into Nuevo Leon. It occurs usually at high elevations in relatively dry mountains. The species is distinguished by its biennial fruition and its coarsely dentate coriaceous leaves with strongly revolute margins and densely fulvous-tomentose lower surfaces.

Quercus Gravesii Sudw. U. S. Dept. Agric. Misc. Cir. 92: 86 (1927); Muller, Am. Midl. Nat. 24: 724. *fig. 16* (1940).

Quercus coccinea var. *?microcarpa* Torr. Bot. Mex. Bound. 206 (1859).
Quercus texana var. *chesosensis* Sargent, Bot. Gaz. 65: 423 (1918).
Quercus texana var. *stellapila* Sargent, Bot. Gaz. 65: 424 (1918).
Quercus stellipila Parks in Cory, Rhodora 38: 405 (1936).
Quercus chesosensis Muller, Am. Midl. Nat. 18: 850 (1937).

VERNACULAR NAMES: Encino colorado; Encino.

COAHUILA: Sierra del Carmen, Aug. 26, 1936, *Marsh 591;* Jardin del Sur, Sept. 3, 1936, *Marsh 768;* Sierra del Carmen, Cañon Sentenela, *Wynd & Mueller 534, 600, 608, 651;* near Piedra Blanca, igneous hills, *Wynd & Mueller 500;* open country between Santo Domingo and Piedra Blanca, *Wynd & Mueller 493;* Rancho Agua Dulce, Sierra San Manuel, *Wynd & Mueller 234, 330, 383;* ravines near Puerto Santa Ana, *Wynd & Mueller 234;* Palm Canyon, *Marsh 369;* Sorpresa Spring, *Marsh 337;* Sierra Gloria, *Marsh 1965, 2001;* Bocatoche, north slope of Sierra del Oso, abundant along arroyo and scattered on slopes, moderate tree up to 30 ft. tall with hard furrowed gray bark and on upper limbs bark in flat plates, *Muller 3135;* Puerto San Lazaro, Sierra San Lazaro, small to moderate tree to 25 ft. tall, trunk 1 ft. thick, abundant on talus slopes, *Muller 3086, 3087;* northwest slopes of Sierra San Lazaro, *Wynd & Mueller 167, 168, 171;* Hillcoat Canyon west of Buena Vista, July 13, 1938, *Marsh 1275, 1297;* Hillcoat Mesa lying west of Encantada Ranch, July 25, 1938, *Marsh 1429;* Cañon San Enrique, eastern side of Sierra Encantada west of Rancho Buena Vista, common on hillsides, shrub up to 4 m. tall, *Stewart 1392, 1403;* Sierra del Pino, La Noria, common along arroyos, in clumps with 10–20 small trunks from one root, 10–15 ft. tall, *Johnston & Muller 438;* Sierra del Pino, central parts of sierra north of La Noria, dense pine forests and along arroyos, becoming 40 ft. tall, trunk 18 inches thick, *Johnston & Muller 558;* Sierra del Pino, Cañon Ybarra, fairly common on arroyo-banks, tree 5 m. tall, *Stewart 1868;* escarpment on west side of Potrero de la Mula, common tree on middle slopes, 10–20 ft. tall, *Johnston 9209;* Sierra Madera, Cañon Charretera, common tree or large shrub on flats and along arroyos below conifer forests, 20–25 ft. tall, *Johnston 8922;* Sierra Madera, Cañon Charrereta, the common large oak along canyons in the lower parts of the conifer forests, tree 30–40 ft. tall, *Johnston 9045;* Sierra Madera, Cañon Pajarito, abundant constituent of upper arroyo forests, tree to 30 ft. tall, trunk 1 ft. thick, *Muller 3172.*

Ranging from the Davis Mts. in trans-Pecos Texas south to central Coahuila. Until 1936 the species was known only from Texas, but its distribution and abundance in Coahuila are greater than north of the Rio Grande. The deeply incised leaves, with scant pubescence except in the

axils of the veins beneath, and the scarlet color of the foliage in the autumn are very suggestive of *Q. texana* Buckl. and *Q. coccinea* Muench. These characters amply distinguish the species from all others in our range. It is common and conspicuous in mesic forests in canyons in both limestone and igneous mountains.

In addition to the twenty-four species listed above, a number of other species probably occur in our area and may be expected about its margins. A large number of oaks are characteristic of the mountains of Nuevo Leon and of the highlands of western Chihuahua and Durango, and some of them are no doubt present in the poorly botanized mountains of southeastern Coahuila and on the hills and mountains along our western border. Trelease has described and illustrated many of these species in his monograph. Notes and descriptions of additional species of this flora have been published by Muller, Jour. Arnold Arb. 17: 160–179 (1936) and Am. Midl. Nat. 27: 470–490 (1942). Among the oaks of western Texas, illustrated, described, and discussed by Muller, Am. Midl. Nat. 24: 703–728 (1940), there are five species which may be expected in northern Coahuila and Chihuahua: *Q. Vaseyana, Q. turbinella, Q. Tharpii, Q. graciliformis,* and *Q. robusta.* The three last-named are known only from the Chisos Mts.

ULMACEAE

Ulmus multinervosa Muller, Am. Midl. Nat. 18: 842 (1937).

COAHUILA: Rancho Agua Dulce, wooded canyon on eastern slope of Sierra San Manuel, small or moderate-sized tree up to 15 m. tall, *Wynd & Mueller 338* (ISOTYPE).

This species of elm is known only from the type locality. It is closely related to *U. divaricata* Mueller of the Sierra Madre south of Monterrey.

In the Sierra Madera, in central Coahuila, just west of Hacienda del Sierra Madera, there is a canyon called "Cañon del Ulmo." I have been informed by local people that the tree giving the canyon its name is not known to grow elsewhere in the region centering about Ocampo. It may possibly represent *U. multinervosa.*

Celtis pallida Torr. Bot. Mex. Bound. 203 (1859).

VERNACULAR NAMES: Granjeno; Acebuche.

COAHUILA: Allende, *Marsh 1807;* 11 mi. south of Allende, *Johnston 7014;* Hac. Mariposa, *Wynd 671;* Rancho Babia, *Marsh 1202;* Santa Anna Canyon, *Marsh 468;* Muzquiz, *Marsh 2106;* Monclova, *White 1752;* San Francisco, about 50 mi. south of Monclova, *Wynd & Mueller 95;* Cuatro Cienegas, *White 1880;* 9 mi. northwest of El Oro, road to Sierra Mojada, *White 1078;* 11 km. northeast of Jimulco, *Stanford et al. 83a.* CHIHUAHUA: Near Lake Santa Maria, 1899, *Nelson 6427;* near Chihuahua, 1908, *Palmer 113;* Meoqui, 1936, *LeSueur 597;* near Ojito, 1847, *Gregg;* Ojo de San Bernardo, 1847, *Gregg.*

A dense bush 2–4 m. tall, with stiff intricate spinescent branches, which is common in rocky soil, especially along arroyos and on the higher slopes of broad valleys. The small orange-colored drupes are edible. The species ranges from south-central Texas to southern Arizona and south in the arid parts of Mexico to Oaxaca, and from southern Florida south in the drier

parts of the West Indies. Benson, Am. Jour. Bot. 30: 236 (1943), has recently taken up the name *C. tala* var. *pallida* (Torr.) Planch. as the proper one for our plant. The North American species is related to the shrub of southern South America, but can be separated by its firmer, scabrid, usually opaque, usually smaller, less toothed leaves and less spinescent branchlets. In a genus in which specific characters are notoriously few and weak, the differences seem reasonably adequate for the continued recognition of our North American plant as specifically distinct. The South American species is much more variable than *C. pallida*. As Baehni, Candollea 7: 202 (1936), has indicated, the proper name for the southern species is not *C. tala* Gillies (1849), but *C. spinosa* Spreng. (1825).

Celtis Lindheimeri Engelm. ex Koch, Dendr. 2: 434 (1872).

VERNACULAR NAME: Palo blanco.

COAHUILA: Hac. Mariposa, *Wynd & Mueller 258;* Yerda Spring, Muzquiz, *Marsh 263;* Monclova, *White 1705;* Sierra Gloria, *Marsh 2218;* Sierra Hechiceros, Cañon Indio Felipe, *Stewart 179.*

A tree distinguished in our area by its ovate leaves, which are distinctly cordate at the base, rough above, hairy beneath, and at times dentate on the margins. The original material of this species, from near New Braunfels, Texas, has its leaves somewhat more abundantly hairy beneath but is otherwise similar to the specimens from Coahuila.

Celtis laevigata Willd. var. **brachyphylla** Sargent, Bot. Gaz. 67: 225 (1919).

VERNACULAR NAME: Palo blanco.

COAHUILA: Allende, *Marsh 1811;* Hac. Mariposa, *Wynd & Mueller 261;* Monclova, *Marsh 1707;* Sierra Gloria, *Marsh 1983;* Cañon Bocatoche, *Muller 3121;* Saltillo, 1898, *Palmer 160;* Sierra Guajes, Cañon Milagro, *Stewart 1727;* Sierra del Pino, Cañon Ybarra, *Stewart 1829;* canyon at San Antonio de los Alamos, *Johnston & Muller 953.*

This is a form of *C. laevigata* differing from the typical form in having shorter and proportionately broader leaves. The usually ovate leaves are bright green, smooth and glabrous above, and glabrous or practically so beneath. The petioles are usually glabrous. It appears to be confined to the western borders of the range of typical *C. laevigata,* in eastern Coahuila and adjacent Texas.

Celtis reticulata Torr. Ann. Lyc. N. Y. 2: 247 (1828).

VERNACULAR NAME: Palo blanco.

COAHUILA: Jardin del Sur, *Marsh 774;* Yerda Spring, Muzquiz, *Marsh 264;* Cañon Bocatoche, *Muller 3121a;* trail between south end of Hillcoat Mesa and Buena Vista, *Marsh 1499, 1500;* Sierra Cruces, Cañon Tinaja Blanca, *Stewart 2256;* 3 km. southeast of Santa Elena, *Stewart 364;* Carrizo, south base of Sierra Cruces, *Stewart 2169.* CHIHUAHUA: Chihuahua, 1908, *Palmer 148;* 32 mi. north of Escalon on road to Jimenez, *White 2074.*

A common and characteristic plant of the plateau, growing singly or in small groves along arroyos. An unkempt tree of rather disconsolate appearance, usually 3–5 m. tall. The cited specimens represent the form of the species found in trans-Pecos Texas. Its pallid thickish rigid leaves vary from lanceolate to ovate. They are scabrid above and hairy beneath. The species intergrades with *C. laevigata* var. *brachyphylla* and *C. Lindheimeri,*

but seems to be a plant of the higher more arid country to the west of these species.

MORACEAE

Morus microphylla Buckl. Proc. Acad. Nat. Sci. Phila. 1862: 8 (1863).
Morus microphilyra Greene, Leaflets 2: 120 (1910).

VERNACULAR NAME: Mora.

COAHUILA: Sorpresa Spring, Hacienda Mariposa, *Marsh 340;* Cañon Milagro, Sierra Guajes, tree 4 m. tall, *Stewart 1712;* San Antonio de los Alamos, watered canyon, tree 10–20 ft. tall, *Johnston & Muller 919, 920, Johnston 8263;* Cañon Indio Felipe, Sierra Hechiceros, tree 3–7 m. tall in watered canyon, *Johnston & Muller 1347, Stewart 162, 1347.* CHIHUAHUA: 1 km. southeast of Rancho Madera, southeast base of Sierra Rica, tree 4 m. tall, *Stewart 2449;* Chihuahua, river bank, bush to small tree, fruit black, edible, 1908, *Palmer 149;* side canyons off Sacramento River northeast of Chihuahua, April 6, 1886, *Pringle 707;* Santa Eulalia hills, Apr. 4, 1886, *Wilkinson;* west of Meoqui, 1936, *LeSueur 598.*

A tree, usually along streams, ranging from central Texas to Arizona and south to northeastern Sonora and northern Nuevo Leon. The species is somewhat variable in leaf-shape. The type of *M. microphilyra* was based on collections from the "Santa Eulalia Plains" collected by Wilkinson in 1885.

Morus alba L. Sp. Pl. 986 (1753).

VERNACULAR NAME: Mora.

COAHUILA: Hermanas, 1939, *Marsh 1600;* Monclova, 1939, *White 1778.*

The above-cited specimens are probably from plants growing under cultivation.

Morus rubra L. Sp. Pl. 986 (1753).

COAHUILA: Saltillo, 1887, *Sargent.*

Morus celtidifolia H.B.K. Nov. Gen. et Sp. 2: 33 (1817).

VERNACULAR NAME: Moral (Gregg).

COAHUILA: Saltillo, March 29, 1844, *Gregg;* Saltillo, 1905, *Palmer 563;* Saltillo, 1887, *Sargent.*

A species of central Mexico extending north to Monterrey and west into Coahuila.

URTICACEAE

Boehmeria cylindrica Sw. var. **Drummondiana** Wedd. in DC. Prodr. 16^1: 202 (1869).

COAHUILA: Muzquiz Swamp, *Marsh 909.*

Entering our area from Nuevo Leon and eastern and southern Texas.

Parietaria floridana Nutt. Gen. Pl. 2: 208 (1818).

COAHUILA: Sierra del Carmen, Cañon Sentenela, *Wynd & Mueller 623;* Hermanas, *Marsh 1598;* Muzquiz, *Marsh 2114;* 6 mi. east of Saltillo, 1880, *Palmer 1267;* Saltillo, 1898, *Palmer 133;* west end of Sierra Madera, canyon 2 km. southeast of Puertecito, *Johnston 9315;* San Antonio de los Alamos, *Johnston 8267;* Sierra Cruces, Cañon Tinaja Blanca, *Stewart 2260;* arroyo cut in gypsum near Santa Elena, *Johnston & Muller 234;* Sierra Mojada, near head of Cañon Calabasa, *Stewart 2211.* CHIHUAHUA: Sierra Santa Eulalia, 1885, *Pringle.*

A weak, usually sprawling herb growing in sheltered places in arroyos or about cliffs; not common. Widely distributed across southern parts of the United States and in northern Mexico.

Urtica gracilenta Greene, Bull. Torr. Bot. Cl. 8: 122 (1881).
Urtica granulosa Blake, Jour. Wash. Acad. 14: 284 (1924).

COAHUILA: Cañon Calabasa, Sierra Mojada, rocky arroyo in deep canyon, in shade, not common, *Stewart 2196*.

Arizona to trans-Pecos Texas (Davis Mts.) and southward in the Sierra Madre of Chihuahua.

Urtica chamaedryoides Pursh, Fl. Am. Sept. 113 (1814).

COAHUILA: Muzquiz, Dec. 5, 1936, *Marsh 1054, 1056*.

Ranging from the eastern United States south to southern Mexico.

Urtica spirealis Blume, Mus. Bot. Lugd.-Bat. 2: 152 (1856).

COAHUILA: Sierra Gloria, *Marsh 1961*.

Ranging from Tamaulipas and Nuevo Leon south to central Mexico. The type was collected between Tampico and Real del Monte (*Berlandier 349*). The material from Coahuila has few stinging hairs and has the lower leaf-surfaces with fine appressed hairs. Similar forms have been collected in Nuevo Leon and Tamaulipas, as has also the greener typical form with abundant stinging hairs. Some forms of the species seem to differ from *U. chamaedryoides* chiefly in having the aments slender and elongate rather than dense and glomerate.

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THE COMPARATIVE MORPHOLOGY OF THE WINTERACEAE VI. VASCULAR ANATOMY OF THE FLOWERING SHOOT

CHARLOTTE G. NAST

With four plates and one text-figure

Two previous papers (Bailey and Nast, 2, 3) of this series have dealt with the vascular anatomy of the stamens and carpels of the Winteraceae. In order to complete a floral anatomical study of the family, the present paper will be devoted to an examination of the pedicellar and toral vascular systems and to a discussion of certain implications arising from that examination.

MATERIAL AND METHODS

Herbarium material of twenty-six species of *Drimys, Bubbia, Pseudowintera,* and *Belliolum* was available for dissection and sectioning. *Zygogynum* and *Exospermum* are not included because no adequate floral specimens were obtainable. Although serial sections were indispensable for tracing the details of the intricate vascular system, flowers cleared in a weak solution of NaOH (Bailey and Nast, 2) were helpful in observing the general vascular pattern and for checking with the sectioned specimens. All material was first heated in water and then treated in NaOH before embedding in paraffin. The NaOH not only restores the specimens most nearly to their original size and shape, but also frees the cells from extraneous substances, which interfere with the clarity of the vascular strands. The usual alcohol-xylene-paraffin embedding method was followed. Slides were stained with Haidenhain's haematoxylin and safranin and mounted in clarite.

The vascular cylinder was drawn as if opened and flattened out in *figures 7, 9,* and *12,* and the vascular strands were depicted to show as nearly as possible their approximate size and the size of the interfascicular regions. Some slight distortions occur in order to make room for appendage traces. Small traces are somewhat enlarged for clarity in reproduction. In *figure 11* the toral bundles are represented by xylem and phloem, and the traces by xylem only.

TERMINOLOGY

It will be necessary, before beginning a description of the floral anatomy, to discuss the terminology used in this article. There has been great confusion and looseness in the use of stelar nomenclature. It seems desirable, therefore, to refer to the original use of stelar types to determine the most appropriate term for the many-bundled angiospermic stele. In 1899 Jeffrey (7) used *siphonostele* as referring to a tubular vascular axis in contrast to protostele. He subdivided the siphonostele into *phyllosiphonic* stele, one with foliar gaps, and *cladosiphonic* stele, one with ramular or branch gaps

and no foliar gaps. The siphonostele may be either *ectophloic* or *amphiphloic* (8). When the siphonostelic central cylinder ". . . ceases to be obviously tubular . . ." he referred to it as *adelosiphonic* (9). In 1901 Gwynne-Vaughan (6) defined the term *solenostele* as ". . . a single hollow cylinder with phloem and phloeoterma on either side, the complex continuity of which is interrupted only by the departure of the leaf-traces; the gaps thus produced being closed up in the internode above before the departure of the next leaf-trace." He further stated that "According to Jeffrey's terminology, solenostely would be regarded as a special type of *amphiphloic phyllosiphony*." Thus the tendency to consider solenostele and siphonostele as synonymous is erroneous if original definitions are to be considered. In 1902, Brebner (4) used the term solenostele according to Gwynne-Vaughan's definition and coined the new term *dictyostele*, "A vascular tube with large 'overlapping' leaf-gaps, so that the whole structure becomes a network of vascular strands or meristeles. The meristeles are concentric." He further defined dictyostele ". . . as *siphonic* when the network is simple or tubular and *adelosiphonic* when complex, i. e., ceasing to be obviously tubular." The erroneous use of dictyostele in anatomical articles and in textbooks as a term for a dissected siphonostele with either collateral or bicollateral bundles is unfortunate, since Brebner was very definite in stating that the bundles of a dictyostele are *concentric*. Furthermore he applied dictyostele to a special type of *fern* stele, and used the term *eustele* for vascular cylinders such as are present in most angiosperms. His definition, "It (eustele) consists of a ring of collateral or bicollateral meristeles, and includes the pericylic and medullary ground tissue," very clearly refers to the "dissected" angiospermic type of stele. The inclusion of pericycle in the definition is unfortunate because of the present-day controversy over the true nature of the pericycle. However, eustele seems to be the most appropriate term and will be used in this article.

Recent work has brought out the fact that dicotyledonous steles are composed of the lower extensions of leaf-traces and, except in certain aquatics, are not made up of cauline bundles but of foliar ones. Thus, there is no procambial nor vascular tissue above the last-formed leaf, and there is an increase in the number of bundles of the stele progressively down the stem as the number of leaves attached to the stem increases. If viewed in three dimensions, the *primary* vascular system is a series of leaf-traces, the lower extensions of which form a eustele whose bundles are arranged cylindrically. Within this stele anastomoses of bundles occur in various ways depending upon the species of plant. It is questionable, therefore, whether foliar gaps, comparable to those found in siphonostelic ferns, are recognizably present in a *primary* vascular cylinder of the eustelic type. In any case, the parenchymatous interfascicular parts of such a stele are so diverse and extensive that the limits of hypothetical foliar gaps are not detectable. Clearly definable gaplike structures appear only after the formation of secondary tissue and are then parenchymatous lacunae in the *secondary* body. Since the flower is a shoot whose primary vascular stele is formed by strands

of the appendages in basically the same manner as in a vegetative apex, and since the association of the traces with the interfascicular regions may be very complex, the term gap will not be used. The parenchymatous regions between the bundles will be referred to as *interfascicular regions.*

Leaf-trace has been used as a collective term for all strands "entering" a leaf (European and older workers), and also for each strand to a leaf, or each strand or strands from a single "gap" (American and more recent workers). For reasons which will become apparent in the text, the concept of a single strand as a trace will be followed here, the trace being that part of the strand between the base of the appendage and its point of departure from the stele or from a cortical bundle (see below). Thus, strands which divide in the cortex will be considered *double traces,* whereas stelar bundles which divide and give rise to two or more strands within the stele and then exit as separate strands will be considered as separate traces. Furthermore, bundles which "leave" the stele and later divide in the cortex into two or more traces that "enter" *different* appendages will be called *cortical bundles.*

INFLORESCENCES

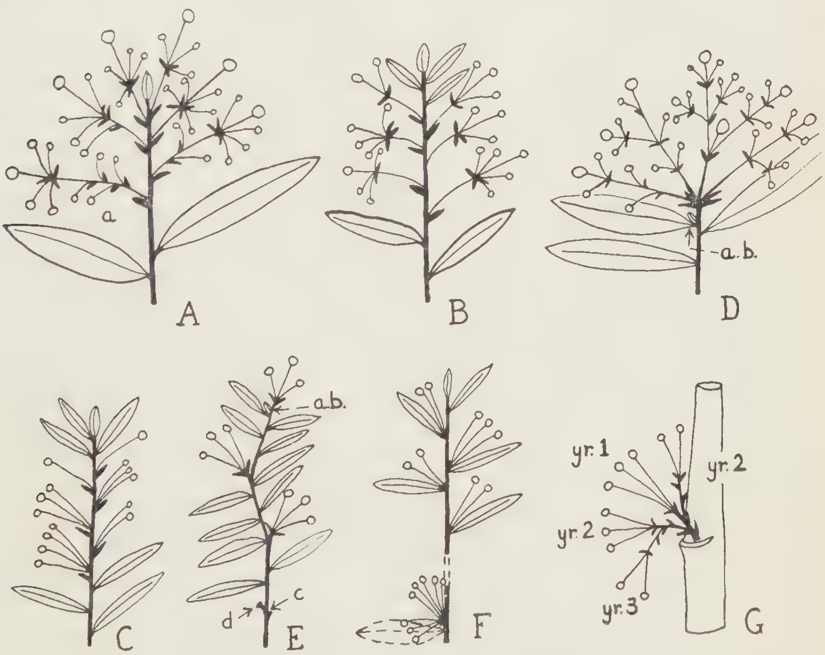
According to Parkin's (10) terminology, the inflorescences of the Winteraceae are either intercalary or pseudoterminal. The latter type gives rise to a sympodial branching system, whereas the intercalary type produces a monopodial branching system. The inflorescences of *Drimys* are intercalary, that is, the inflorescences are borne in axils of bracts (or occasionally leaves) below the terminal bud, which later produces leaves and inflorescences in alternate periods of growth. The flowers of *Drimys* Section *Wintera* are variable in number in each of the cyme-like inflorescences and are usually pedunculate. The whole group of axillary inflorescences may give the appearance of an umbel-like structure, especially before the terminal bud has developed into foliage (*text-fig. A*). In *D. granadensis* var. *grandiflora* Hieron. (*text-fig. A*) each inflorescence consists of an apical flower, below which is a whorl of a variable number of flowers subtended by bracts. The number of these bracts does not necessarily correspond to the number of flowers they subtend. Below this whorl there may or may not occur one to four spirally arranged flowers (*a*), each subtended by a bract. An examination of the American species of *Drimys* reveals that a reduction from this rather complex type of inflorescence evidently has occurred in this group until only two or three flowers remain in the inflorescence (*D. brasiliensis* var. *campestris* (St. Hil.) Miers) (*text-fig. B*).

In the Section *Tasmannia* of *Drimys* the flowers are borne singly or in fascicles of two to four flowers (usually three). A bract (occasionally a leaf, e. g. *D. Brassii*) subtends each flower or fascicle. These flowers are without peduncles (*text-fig. C*).

The inflorescence of *Bubbia* consists of cyme-like pedunculate flower-groups developing in axils of bracts at the terminus of a branch (*text-fig. D*). The branch continues its growth from a bud in the axil of a leaf

immediately below the inflorescence (*a.b.*). It is the pseudoterminal inflorescence as defined by Parkin, who cites species of "*Drimys*" (really species of *Bubbia* and *Belliolum*) as examples. The pseudoterminal inflorescence, according to Parkin, has developed from an intercalary type by the abortion of the terminal bud. In other words, a group of axillary inflorescences are congested at the apex of a stem and the structure as a whole appears to be terminal because the apical bud is absent. The number of flowers in the inflorescences of *Bubbia* varies considerably; thus, there is formed a series of inflorescences from very complex, much branched types to fairly simple types with only a slight amount of branching. Occasionally an inflorescence is borne in the axil of a leaf (e. g. in *B. longifolia* A. C. Sm.) below the pseudoterminal flower-cluster.

Belliolum has pseudoterminal inflorescences very similar to those of *Bubbia* and also with great variation in the complexity of the flower-cluster. However, many species have inflorescences reduced to three non-pedunculate flowers (*text-fig. E*) and with only two bracts present. The inflorescence-bearing shoot persists after the development of the vegetative bud and usually appears to be lateral on older branches (*d*).



FIGS. A–G. Diagrams of inflorescences. A. *Drimys granadensis* var. *grandiflora* Hieron.; B. *D. brasiliensis* var. *campestris* (St. Hil.) Miers; C. *Drimys* Section *Tasmannia;* D. *Bubbia;* E. *Belliolum Kajewskii* A. C. Sm.; F. *Pseudowintera;* G. *Pseudowintera:* short shoot drawn with elongated internodes to show nature of branching. *a.* spiral flowers; *a. b.* axillary buds; *c.* leaf scar; *d.* inflorescence scar; *yr. 1, 2, 3.* seasonal growth of short shoot.

The inflorescences of *Exospermum* and certain species of *Zygogynum* are essentially similar to the more reduced forms found in *Belliolum*. In other species of *Zygogynum* (*Z. Vieillardi, Z. Bailloni, Z. bicolor*) the flowers are solitary and terminal. If Parkin is correct in assuming that the pseudoterminal inflorescences of *Bubbia* and *Belliolum* were derived by the loss of the terminal buds from the intercalary inflorescences of *Drimys*, then the solitary terminal flower of *Zygogynum* must be an evolved form. It could not be a primitive terminal flower as Parkin contends. Growth of the axis is continued by an axillary bud basal to the terminal flower.

In *Pseudowintera* the main axis of the branch bears a terminal foliage bud. The flowers are often described as axillary and fasciculate. However, they are actually borne terminally on extremely compressed short shoots which bear several very small reduced bracts (*text-fig. F*). These short shoots are capable of bearing flowers each year for several seasons. Buds in the axils of the bracts produce in the second year of growth other compressed shoots with flowers and bracts. These secondary shoots in turn produce buds in the axils of their bracts, buds which develop the third seasonal growth of flowers. If this short shoot were elongated as drawn in *text-figure G,* it is apparent that the structure is a branching system so reduced that only flowers and bracts are formed. Each segment of this system is comparable to the reduced pseudoterminal inflorescences of *Belliolum, Exospermum,* and *Zygogynum*. However, a foliage shoot may develop from a bud in the axil of a bract in the second growth season instead of a reduced flower-shoot.

PEDICELS

The peduncles, i. e. primary, secondary, or tertiary rays of the inflorescences, usually have well-developed eusteles of a variable number of bundles. This is especially true of *Drimys*. The bracts subtending the inflorescences of *Drimys* have three traces with distinct lacunae in the secondary body (*fig. 1*) except for occasional bracts with two traces. The bracteoles subtending the pedicels of the flowers in *Drimys* also have three traces in most specimens examined, although bracteoles with one trace are fairly prevalent. In *Bubbia*, however, all bracteoles examined have one trace (*fig. 2, A* and *B*), each trace being extremely minute even in large flowers of *Bubbia Clemensiae* A. C. Sm. These traces in *Bubbia* arise at a higher level than the bracteoles, necessitating a downward bending of the trace for a short distance (*fig. 2, B* and *A*). In laterally borne fasciculate flowers (*fig. 1*) the vascular cylinder of the branch is greater in diameter at those regions where flowers arise. A single bract subtends each flower (*ped.* in *fig. 1, C* and *D*) or each floral cluster. Extra bracts may be present (*fig. 1, A* and *B*). Each thickened area of the stele breaks up into a number of bundles as it leaves the central cylinder and almost immediately assembles into steles of the floral pedicels (flower cluster 3, *fig. 1, F–I*). These pedicels may contain one or two concentric bundles (*fl. cl. 2, fig. 1, H*) or a cylinder of bundles. The number of bundles present in the base of the pedicel varies greatly.

The formation of pedicels from the rays of the inflorescences and the formation of primary, secondary, and tertiary rays in a flower are similar in both *Drimys* and *Bubbia*. The number of bracteoles for each group of flowers varies from two to five in *Drimys* and is constantly two in *Bubbia*. The number of flowers in the cluster, however, is not indicative of the number of bracteoles. The vascular cylinder of the ray or peduncle separates into the steles of the floral pedicels as depicted in *figure 2*. One flower of the cluster is terminal. The number of bundles entering each pedicel varies from two large bundles to well-dissected eusteles (*figs. 3* and *5*). Distinct cylinders are always present in the pedicels of *Belliolum*, and almost always in *Drimys* Section *Wintera*. In *Drimys* Section *Tasmannia* and in *Pseudowintera* the number of bundles is less. Often there are only one, two, or four. Two wide interfascicular regions, one above the bracteolar trace, the other above the attachment of the bundles to the peduncular cylinder, are often retained for long distances in the pedicel (*lg. rays, figs. 4* and *5*). In flattened pedicels these interfascicular regions are located in the flattened sides of the cylinder and the vascular bundles are grouped in the two narrow arcs of the cylinder (*figs. 3* and *4*). However, all large interfascicular regions are not always identical to these interfascicular regions. The bundles of the stele (*fig. 7*) branch and anastomose throughout the length of the pedicel, thus producing new interfascicular regions and eliminating some of the lower ones (*fig. 6*). Accessory interfascicular regions[1] (*acc. r., fig. 7*) are also produced, interfascicular regions which are not related to any external appendage of the pedicel and which are due to a splitting of the bundle. If the interfascicular regions of the pedicel (*fig. 7*) are followed upward into the torus (*fig. 9*), it will be seen that most of them are closed at some level in the torus. Furthermore, many of the interfascicular regions, as well as the accessory ones, extend several internodes and have no relationship to appendages even in the torus. Interfascicular regions of this nature are most prevalent in *Drimys* but occur also to a lesser degree in flowers of the other genera (*acc. r., fig. 12*). Thus the vascular system of the pedicel and the torus should be considered as a network of branching, rebranching, and anastomosing strands rather than as a stereotyped cylinder dissected by the exit of traces to appendages. This interpretation is substantiated by the examination of cleared flowers where the entire vascular system is seen as a unit. It will be made clearer when the torus is examined in detail.

CALYX

Bubbia and *Drimys* are separated taxonomically by their calyces. *Drimys* has a calyptrate calyx with two lobes, rarely three. In *Bubbia* the calyx does not enclose the flower-bud and the number of lobes is more variable (2–9, usually 3). *Belliolum* has an entire or an inconspicuously

[1]Also known as perforations (F. O. Bower. The Ferns. Vol. I. 1923; O. Posthumus. On some principles of stelar morphology. Amsterdam. 1924. Trans.). However, the term perforation gives a connotation of a hole, to which the author objects.

lobed calyx, while *Pseudowintera* has an entire, crenulate, or bilobed calyx (Smith 11, 12, 13). The calycine traces of the Winteraceae are predominantly branches of bundles and not whole bundles of the central vascular cylinder. The traces usually arise from the sides of the stelar bundles, occasionally from the center. More than one trace may be adjacent to the same interfascicular region (center of *fig. 9*), which is widened when the traces "depart."

The number of traces to the calyptrate calyx of *Drimys* varies from five to eleven. Since three traces are found in the leaves, bracts, and most bracteoles, three traces can be considered the basic number for each part of the calyptra. If this is true, then three-fifths of the calyces of *Drimys* examined would be two-parted or bilobed, and two-fifths would be three-parted or three-lobed. This raises a question regarding Dr. Smith's statement (12:6) that the sepals of *Drimys* Section *Wintera* are usually two, *rarely three* in number. However, in buds where the two free tips of the sepals were unbroken, it was found that one sepal received a greater number of traces, four traces in a seven-trace calyptra, often five in an eight-trace calyptra, and six in a ten-trace calyptra. This condition may be interpreted in two ways: (1) the number of traces in the sepal whose tip overlaps the tip of the other sepal has been increased because of size difference of the sepals, or (2) this "outer" sepal is really a composite of two sepals which through phylogenetic changes has already lost externally all indications of its two-parted nature except in rare instances.

The number of traces in the calyx of *Bubbia* varies from three (often double traces) to twelve. Each lobe of the calyx receives, basically, three traces, so that in the specimens examined a calyx with two lobes has usually six traces, with three lobes nine traces, and with four lobes twelve traces. However, there may be fewer or more than the usual three traces to each lobe. For example, in *figure 12* one of the two calycine lobes has one trace which is a double trace, and the other lobe has one double and one single trace.

In *Pseudowintera axillaris* (J. R. & G. Forst.) Dandy, all specimens examined have two traces which arise on opposite sides of the toral stele. Although externally the calyces of the two varieties, *P. axillaris* var. *colorata* (Raoul) A. C. Sm. and *P. axillaris* var. *typica* A. C. Sm. (13), appear different, the vascular anatomy suggests for both a two-parted calyx, each part with one trace. The reduction of trace-number may be correlated with the reduced size of the flower in this genus.

The toral vascular system of *Belliolum* is much more complex than those of the other three genera. Here cortical bundles arise from the stele and divide in the cortex to form traces which enter appendages borne on different levels of the torus. This complex type of toral system is very similar to the condition found in *Himantandra* (1). In *B. haplopus* (Burtt) A. C. Sm. there are nine cortical bundles, each of which usually divides into three parts. The central branch is a calycine trace. The lateral branches unite with laterals from the adjacent cortical bundles to form petaline

traces. But in *B. Burttianum* A. C. Sm. the calycine traces arise directly from the stele and branch, anastomose, and rebranch at the base of the calyx. However, cortical bundles are formed in the region of the petals. In *B. Burttianum* there are seven to nine calycine traces, which are assembled into two groups on opposite sides of the toral cylinder. As this species has an inconspicuous bilobed calyx, in contrast to the essentially entire calyx of *B. haplopus*, the position and not the number of the traces seems to indicate the apparent number of sepals. The number of traces would indicate either two or three sepals. *Belliolum haplopus*, with nine uniformly spaced traces, can be considered as having three sepals.

PETALS

The number of petals in the Winteraceae varies from two (rarely one or none) to many. The number of principal veins per petal is usually three or five, and the number of traces either one or three. Occasionally the inner small petals of a flower may have one or two traces instead of the usual three. All petals of the examined specimens of *Drimys* Section *Wintera* and most petals of those of *Drimys* Section *Tasmannia* have one trace. An interesting condition occurs in *D. obovata* A. C. Sm., where the two traces, one to each of the two petals, arise from cortical bundles from which calycine traces also are formed. The petals of *Belliolum* and *Pseudowintera* always have three traces, except for occasional one-trace inner small petals of *Belliolum*. As stated previously, *Belliolum* is distinct from the other genera because of the more complex branching system. In *B. haplopus* the lateral branches of the cortical bundles, which also formed the calycine traces, become lateral traces to the lower petals. In both species of *Belliolum* examined, cortical bundles arise in the petaline region and divide once or twice. One of the branches is always a medium petaline trace, the other (or others) may either immediately become a lateral trace for the next or higher petal or may remain as a cortical bundle which forms lateral traces to the succeeding series of petals. The median trace of the most apical petals usually arises directly from the stele, but occasionally it arises from a cortical bundle which also forms a trace to a stamen. In *B. haplopus* there are about four cortical bundles which remain as cortical bundles up to the base of the carpels, where they stop, never entering any appendage. These cortical bundles may be either those that arose in the calycine or in the petaline regions.

The petaline traces, like the traces of the calyx, are branches of the toral bundles (*figs. 9* and *12*). Occasionally a trace may be double (*fig. 12*, trace 1) or a stelar bundle may divide in the stele to form two traces to the same petal (*fig. 12*, trace at 2) or to different petals (traces 3 and 4). Other complications may arise, such as two small toral bundles uniting in the stele to form one trace (traces 5 and 6). In flowers with three-trace petals, all of the traces may be adjacent to the same interfascicular region or to different interfascicular regions. Furthermore, the traces to one petal may even arise from the same large stelar bundle when the vascular cylinder is composed of a small number of bundles, as in the diagram of *figure 12*.

In flowers with one-trace petals and with many bundles in the toral stele, this congestion of traces does not occur (*fig. 9*). Here, more than one petaline trace is rarely adjacent to the same interfascicular region, although staminal and petaline traces may be adjacent to the same one.

STAMENS

Without exception the stamens in all genera of the family receive one trace. In many places several staminal traces arise from the same interfascicular region, or even from the same one as a petal (*figs. 9* and *12*).

Where many spiral appendages are so congested, as in winteraceous flowers, congestion of the traces will necessarily occur. Also, with more traces to the appendages, the more complex the relation of those traces to the stele becomes. This was shown in the description of the petaline traces of *Bubbia* (*fig. 12*) and also in *Belliolum*. It is also evident in the staminal region, e. g. in *Drimys*, where several traces arise from the same toral bundle and are related to the same interfascicular region. The floral vascular structure, therefore, is really a network of branching and anastomosing stelar strands from which appendicular traces arise in no definite pattern. Because of the shortened internodes and closely compressed floral appendages, these traces seem to unite to the nearest strands, so that a series of traces may be associated with the same interfascicular region which may extend not only for a couple of nodes but throughout the length of the flower.

CARPELS

The carpels are inconstant in number in the winteraceous genera. In the species studied the variation ranged from one to thirteen. All residual vascular bundles of the central cylinder above the lower appendages enter the carpels (*figs. 8, 9, 11,* and *12*). No "superfluous" tissue remains above the carpellary traces, as Eames (5) figures in *Prunus, Actaea,* and *Bauhinia*. The floral apex, which is quite prominent in some species of *Drimys* (*fig. 8, G,* and also *fig. 6* in reference 3), is, therefore, non-vascularized. In *Drimys* and *Bubbia* there are usually only a few fairly large strands remaining after the stamen-traces have made their exit (*figs. 8, E* and *11, C, D*). Often the appearance of a vascular ring in transverse section is lost. In *Pseudowintera* and *Belliolum* a definite ring consisting of many bundles is present. An anastomosing of bundles occurs below the carpels so that the number of bundles is reduced to a greater or less extent. Concentric bundles (*fig. 8, F*), the number corresponding to the number of carpels in the flower, are formed predominantly in *Drimys* Section *Wintera*. Crescent-shaped bundles, one to each carpel (*fig. 10*), are also quite prevalent. These bundles are located in the torus (*fig. 8, E* and *F*) and in the lower part of the carpellary stipe. Each divides into three collateral bundles (two ventrals and one dorsal trace) slightly below the ovarian cavity, or at the base of the carpellary stipe (*fig. 8, F*). In a few instances two or the usual three traces enter the carpel directly from the toral cylinder without a preliminary union into one large bundle. If two bundles enter the carpel, one eventually divides into the two ventral bundles. All these variations

may occur in the same flower. In *Drimys* Section *Tasmannia* one bundle, either concentric or collateral, enters each carpel in the majority of specimens examined. However, there are more cases (a third of the carpels cut) of two- and three-trace carpels than in Section *Wintera.* A few carpels have four or more traces. The long carpellary stipe of *D. stipitata* Vickery usually has one bundle, sometimes two, in the lower half and always two in the upper part. Since uni-carpellate flowers may have any of these vascular patterns, there is no correlation between the number of carpels in the flower and the type of vascular system present. In *Bubbia* the reorganization of the toral bundles into concentric bundles occurs only occasionally. Two and three traces are quite prevalent (*figs. 11* and *12*). The dorsal traces leave the toral system first when three traces enter the carpel. The ventrals are formed by the branching of the few remaining toral bundles. Many of the carpels have four and five traces. Often in a five-trace carpel the two extra strands are two lateral bundles situated between the ventral and dorsal bundles, one on each side of the carpel. However, when more than three traces are present there may be branching, anastomosing, and reassembling of the bundles in the torus or in the base of the carpel. In those carpels with extra large dorsals, as in *B. megacarpa* A. C. Sm., *B. longifolia* A. C. Sm., and *B. monocarpa* A. C. Sm. (see illustrations in reference 3), a number of bundles may unite in the toral cylinder to form the dorsal trace. In the branching, anastomosing, and reassembling of the toral bundles into carpellary traces, bundles from one side of the torus may cross over and unite with strands on the opposite side (*figs. 11, C* and *12*).

In *Pseudowintera* the number of carpellary traces is usually three, often four, and rarely one or five. Although a definite cylinder is left in the torus after the stamen-traces depart, the cylinder is made up of relatively few bundles. In *Belliolum,* however, this residual cylinder is made up of a greater number of bundles (8–16). The dorsal traces in *B. haplopus* depart from the cylinder first and the remaining bundles divide, when fewer toral bundles than ventral traces are present, or anastomose, when a greater number of toral bundles are present, to form the two ventrals. In *B. Burttianum,* which has one carpel in the flower, several bundles unite in the cylinder to form the dorsal strand. This may occur before all of the stamen-traces have departed. The rest of the toral bundles unite into four or five traces which are ventrals and laterals.

DISCUSSION

The floral vascular system of the Winteraceae should be considered as a network of branching and anastomosing strands, with little uniformity in pattern. It is a vascular system which is appendicular rather than cauline, that is, all the bundles of the stele are downward extensions of the appendicular traces or the composite of these extensions. There are no cauline bundles which extend from the pedicel through the torus and end blindly at the apex of the vascular cylinder. The vascularization of these flowers is very similar to that found in foliar stem-tips where leaf-traces form the

stele. Just as in the foliage-tip, there is no vascular tissue developed above the last-formed appendages in the flower. The vascular system differs from that of the foliage-tip in the haphazard manner of the insertion of the traces in the stele and the irregular association of the traces to interfascicular regions. Interfascicular regions may extend from the apex of the torus to the base of the pedicel (*fig. 9,* interfascicular region between third and fourth carpel bundles), or they may be very short. The number of traces associated with an interfascicular region varies greatly, as does the manner in which the traces or their extensions unite within the stele with extensions of the more apical traces. Furthermore, the traces from different appendages may be associated with the same interfascicular regions. These irregularities are due to the large number of appendages crowded within a small area. In a stem-apex where the internodes are longer, the union of trace-extensions within the stele seems to be of a definite pattern[2] and the interfascicular regions are, therefore, of fairly uniform length and distribution. This vascular instability of the flower may be reflecting the phylogenetic changes that are still occurring in this rather primitive group of plants.

The variation in the number of calycine lobes and in the number of traces to the calyx of the Winteraceae indicates that changes have occurred and are occurring in this region. There is evidence that the apparently two-parted calyptrate calyx of *Drimys* actually consists, or formerly consisted, of three sepals. In both *Drimys* and *Bubbia* three traces to each sepal are predominantly found. However, in the two-lobed calyces of *Bubbia* there is a tendency toward a reduction in the number of traces (*fig. 12*). The culmination of reduction occurs in *Pseudowintera,* where one trace enters each of the two sepals. The number of traces to the petals and to the stamens shows nothing unusual, although their mode of insertion in the stele illustrates again the instability of a changing toral vascular system.

The occurrence of concentric and crescent-shaped bundles in the carpellary system is especially interesting. These bundles are remarkably like the bundles often found in petioles and suggest that a petiole-like structure may have occurred in the lower region of the primitive carpel. Not in all cases are these bundles in the stipe itself, but their occurrence in the torus may mean their gradual loss concomitant with the loss of an external petiole-like region. Their prevalence in *Drimys,* where the carpels are the most primitive of the Winteraceae, is significant. However, their more frequent occurrence in the Section *Wintera* is unexplainable, since *Drimys* Section *Tasmannia* has the more primitive carpels of the genus (3). In the other three genera, where modifications of the *Drimys* Section *Tasmannia* carpel occurs (3), the "normal" three-trace condition (or variations of it) is predominant and the petiole-like vascular region is absent.

[2]Katherine Esau. Vascular differentiation in the vegetative shoot of Linum. II. The first phloem and xylem. Amer. Jour. Bot. 30: 248–254. 1943. Note diagrams in *text-figures 1* and *9.*

Carpels with two traces, one trace for the dorsal and one trace for the two ventrals, may be weakly retaining the petiole-like vascular condition which occurs in *Drimys*.

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EXPLANATION OF PLATES

PLATE I

FIG. 1, A–I. *Drimys piperita* Hook. f., *Griswold 44*. Serial segments of the vascular tissue in a flowering shoot with lateral flower clusters. Stele is drawn as solid cylinder because secondary tissue is present. Approx. × 15. FIG. 2, A–E. *Bubbia semecarpoides* (F. v. Muell.) Burtt, *White*. Serial segments of peduncle with bases of the three terminal floral pedicels. Approx. × 12. Bud scale of terminal bud, *b. sc.;* bract, *br.;* flower cluster 1, 2, 3, *fl. cl. 1, 2* and *3;* pedicel, *ped.;* terminal bud, *t. b.*

PLATE II

FIG. 3. *Drimys piperita* Hook. f., *Ramos 19583*. Transverse section from base of pedicel. Approx. × 35. FIG. 4. *Drimys Brassii* A. C. Sm., *Brass 9536*. Transverse section from base of pedicel. Approx. × 42. FIG. 5. *Drimys insipida* (R. Br.) Pilger, *White 3568*. Transverse section of pedicel slightly below torus. Large rays, *lg. r.* Approx. × 42. FIG. 6, A–D. *Drimys brasiliensis* var. *campestris* (St. Hil.) Miers, *Clausen, F. M. 1024472*. Cross-sections of pedicel at levels designated *a–d* in *figure 7*. Arrows indicate position of bundles from left to right in diagram of *figure 7*. Approx. × 45. FIG. 7. Same as *fig. 6*. Diagram of vascular system in pedicel showing branching and anastomosing of strands. Lightly stippled regions mark part of system omitted. Levels drawn in *figure 6* indicated by *a–d*. Accessory ray, *acc. r.*

PLATE III

FIG. 8, A–G. Same as *fig. 6*. Cross-sections of flower at levels designated *a–g* in *figure 9*. A, base of torus; B, level of calyx; C, level of petals; D, level of stamens; E–G, levels in apex of torus and base of carpels. Arrows indicate position of bundles from left to right in diagram of *figure 9*. Sterile apex, *st. ap.* Approx. × 20. FIG. 9. Same as *fig. 6*. Diagram of vascular system in flower. Heavy broken lines represent branching of calycine traces. Petaline traces not marked. Apical strands are traces to the five carpels.

PLATE IV

FIG. 10. *Drimys Winteri* var. *chilensis* (DC.) A. Gray, *Junge*. Cross-section of torus above stamens, showing types of bundles which will enter the seven carpels. Approx. × 30. FIG. 11, A–E. *Bubbia Whiteana* A. C. Sm., *Kajewski 1495*. Cross-sections of flower at levels designated *a–e* in *figure 12*. Arrows indicate position of bundles from left to right in diagram of *figure 12*. Dorsal veins, *dor.;* ventral veins, *ven.* Approx. × 42. FIG. 12. Same as *fig. 11*. Diagram of vascular system in flower. Lightly stippled regions mark part of system omitted. Accessory ray, *acc. r.*

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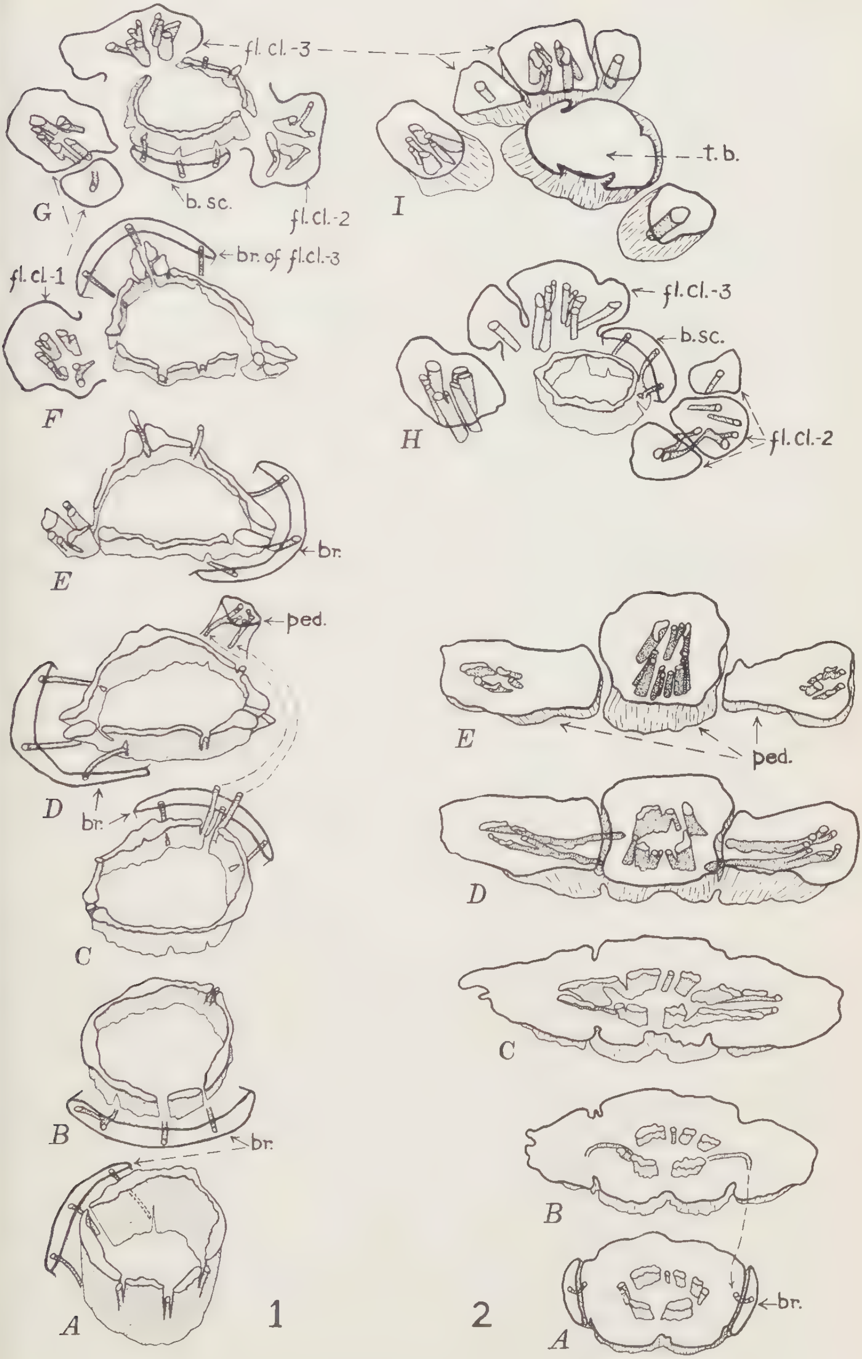
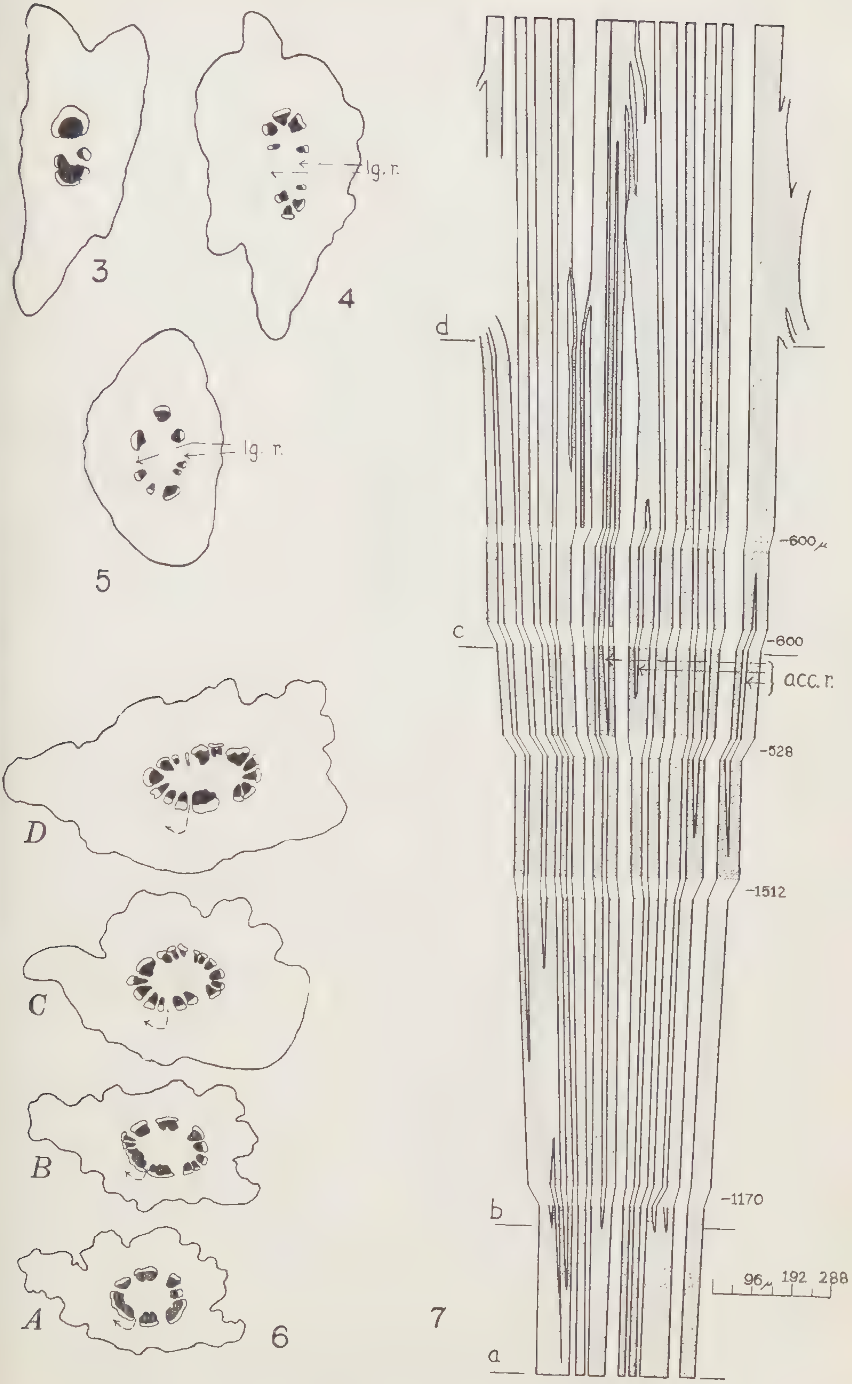


Comparative Morphology of the Winteraceae



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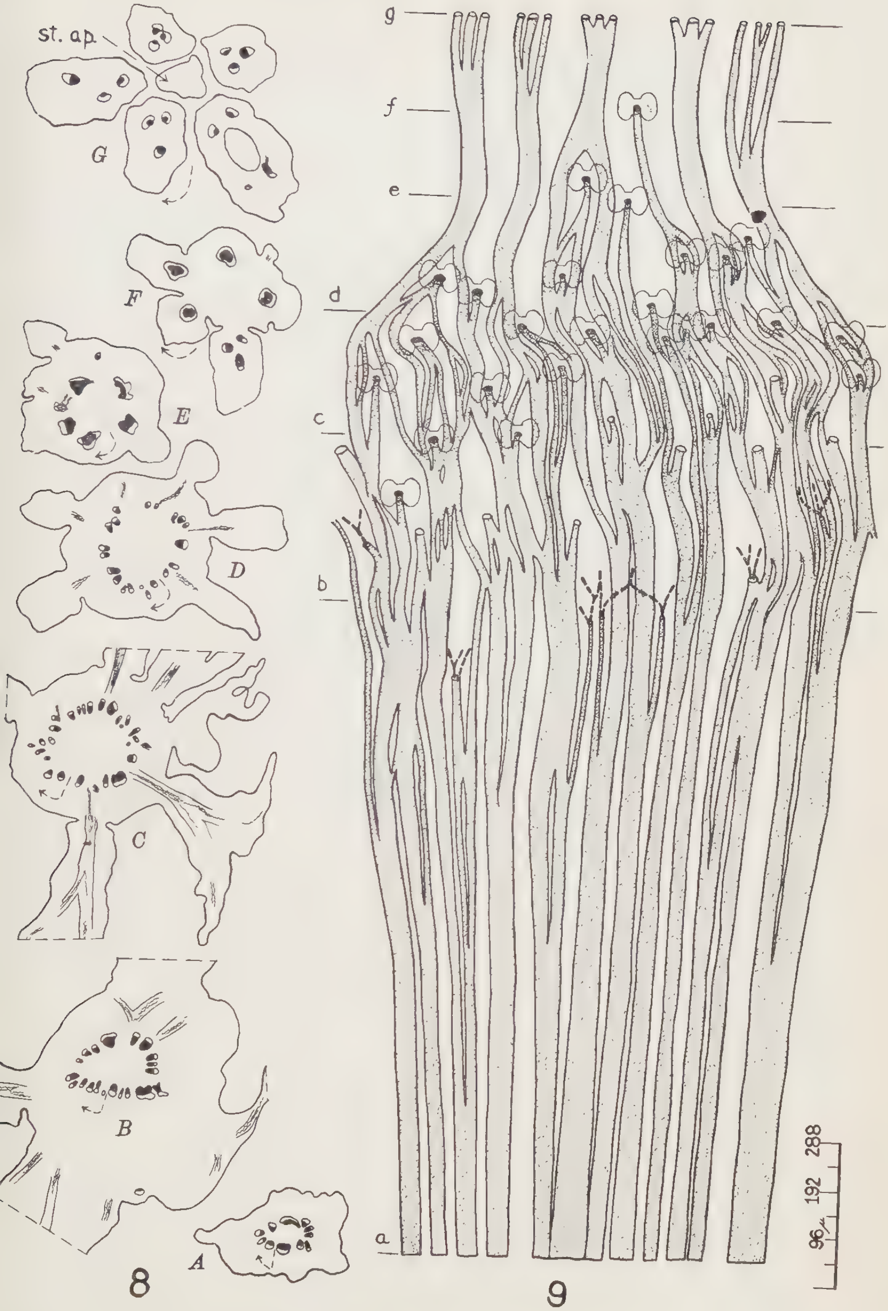

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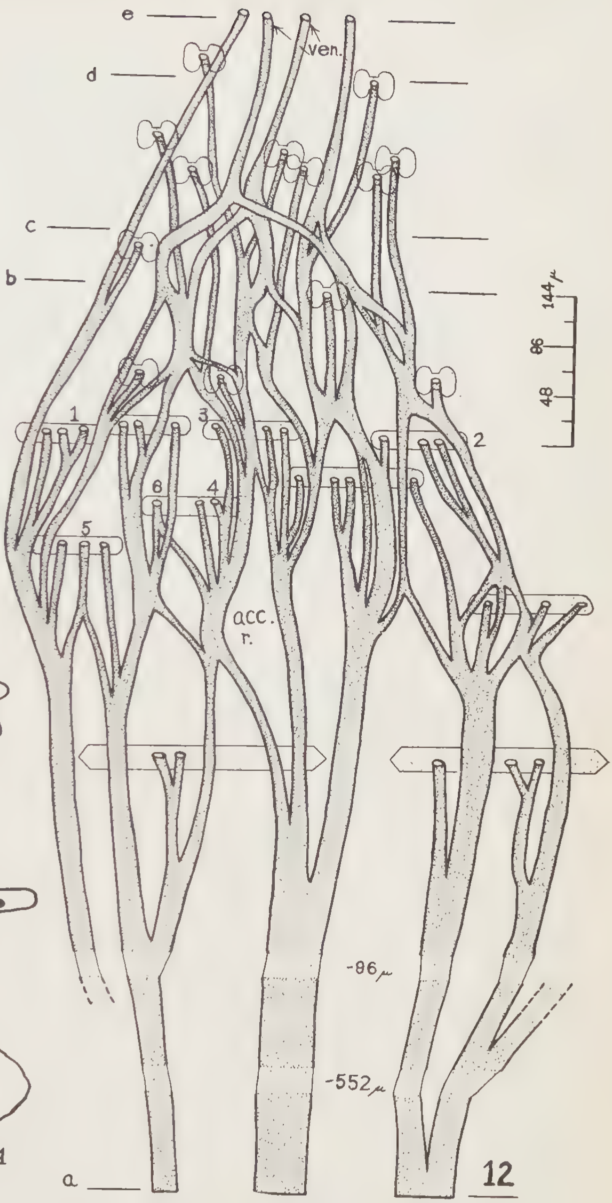

Comparative Morphology of the Winteraceae

EFFECT OF SEED WEIGHT AND SEED ORIGIN ON THE EARLY DEVELOPMENT OF EASTERN WHITE PINE

STEPHEN H. SPURR[1]

With one plate and two text-figures

ALTHOUGH the effect of seed size on the growth and yield of grains and other crop plants has been frequently and intensively studied, little is known about this effect on trees, particularly over a period of more than one growing season. The present experiment was designed to give precise information concerning the effect of seed weight and seed origin on the growth and development of eastern white pine (*Pinus strobus* L.) seedlings over a three-year period. Such information on the factors influencing the growth of an important timber tree is not only of value in amplifying and clarifying existing knowledge of the development and growth behavior of trees, but is also of practical importance, both to the forester growing planting stock, and to the botanist utilizing tree seedlings in precise experiments.

PREVIOUS WORK

Numerous investigations of the relation between seed weight and plant size have been undertaken, mostly on fast-growing, short-lived plants. Investigators have found that seed weight significantly affects plant size during the early stages of plant development. Considerable disagreement exists, however, as to whether this effect of seed weight persists or whether it diminishes in importance, even ultimately disappearing (9).

Seed weight tests involving forest trees have been summarized by Champion (4) and Baldwin (3). Although many of these tests were on a small scale and their results inconclusive when judged by modern statistical standards, they substantially agree that seedling size is influenced by seed size for at least one year. In the few experiments carried on for more than one year, height rather than weight has generally been used as a measure of growth. Furthermore, in several studies, ultimate plant size was related to first-year plant size instead of to seed size. The accumulated evidence, nevertheless, indicates that differences in growth due to varying original seed size tend to disappear within a few years.

In most of the reported tests, the average weight of a group of seeds has been used rather than the weight of individual seeds. McComb (6), however, weighed acorns of chestnut oak (*Quercus montana*) to the nearest

[1]Assistant to the Director, Harvard Forest, Petersham, Mass. This study was suggested by problems on which the author worked under the direction of Dr. P. R. Gast, and was largely supported by the Maria Moors Cabot Foundation for Botanical Research. E. A. Snow and J. W. Wright cooperated in designing and establishing the experiment, while other staff members and graduate students at the Harvard Forest generously advised and assisted the author.

tenth gram and followed the growth of the individual plants through one growing season. He found that acorn weight was clearly correlated with shoot weight ($r = 0.82$), shoot height ($r = 0.79$), and other measures of growth.

Several precise trials have been conducted with pine species by Aldrich-Blake (1, 2), Mitchell (7, 8), and Gast (5). In these studies, a high degree of correlation was noted between seed weight and the weight of the one-year-old seedlings. Gast, in particular, has utilized generalized mathematical growth laws and has developed techniques for adjusting plant weights to eliminate differences due to variations in seed weight.

The present experiment was initiated to examine current conceptions, and to extend to three years our knowledge of the combined effects of seed weight and seed origin on the growth of white pine.

MATERIALS AND METHODS

The experiment consisted essentially of weighing individually one thousand white pine seeds, growing the resulting plants under uniform conditions, keeping an accurate record of each plant, and harvesting one-third of the plants at the close of each growing season. Other variables were introduced by using seed from ten different mother trees growing in four widely separated localities, and by using two growing media: a carefully prepared soil bed and a sand bed subirrigated with nutrient solution.

One hundred seeds of each of ten seed lots were weighed individually to the nearest hundredth of a milligram, disinfected, and stratified at low temperature in specially designed plaster of Paris blocks for two months before planting. Each lot consisted of seed from a single mother tree: three from the Harvard Forest; three from the Pack Forest at Warrensburg, New York; three from the White Mountains of New Hampshire; and one from Uxbridge, Ontario. Empty seed were eliminated at the time of weighing. Individual seed weights varied from 8.2 to 30.8 mg. (Table 1).

TABLE 1.

ORIGIN AND WEIGHTS OF SEED LOTS

Lot	Locality	Seed weight in milligrams[1] Mean	Range
1	Harvard Forest, Petersham, Mass.	14.03	9.0–18.8
2	" " " "	16.36	9.3–21.6
3	" " " "	15.10	10.2–22.2
4	Uxbridge, Ont.	17.20	9.8–26.5
5	Pack Forest, Warrensburg, N. Y.	22.43	16.1–30.2
6	" " " "	13.80	9.6–17.7
7	" " " "	16.30	9.3–12.9
8	White Mountains, N. H.	15.10	8.2–24.1
9	" " "	17.69	11.7–23.3
10	" " "	22.09	10.6–30.8

[1]Germinated seed only.

The soil bed near the headquarters of the Harvard Forest consisted of six inches of gravel for drainage overlain by twelve inches of a mixture of equal parts of nursery soil, sand, and peat, sifted and thoroughly mixed. The sand culture consisted of washed quartz sand ten inches deep in an unpainted galvanized metal box, and was subirrigated three times daily by nutrient solution. The solution used contained 250 parts per million of nitrogen and phosphorus, 125 ppm of potassium and calcium, 100 ppm of magnesium, and 3.4 ppm of iron (ferric citrate) as recommended by Gast (unpublished).

The seed were planted $1\frac{1}{2}$ inches apart in rows spaced at intervals of $1\frac{5}{8}$ inches. Seed location was randomized within rows, and the location of the three rows of each seed lot was randomized within the bed.

At the close of each growing season, approximately one-third of the plants was cut off at the ground line, and both fresh and oven-dry weights obtained. As a result of this annual harvest, the remaining plants were left relatively free to grow during the ensuing season. In order to obtain an adequate sample of certain lots that had germinated poorly, all plants of these lots were harvested before the end of the experiment. Thus, lot 4 was completely harvested at the end of the first growing season, and lots 3, 8, and 9 at the end of the second season. Only one harvest was made from the sand culture, as the remaining plants died during the second season due to neglect caused by the illness of the author.

All data were subjected to statistical analysis after methods outlined by Snedecor (10). In particular, analysis of covariance was extensively adopted.

The terms "significant" and "highly significant" are used in the text only in their statistical sense. A significant difference indicates that the probability is less than one out of twenty ($P = 0.05$) that the difference is due to chance; whereas for a highly significant difference, this probability is less than one out of one hundred ($P = 0.01$).

PERCENT GERMINATION

Petri dish germination tests of 100 unweighed seed from each lot were made on unstratified seed, seed stratified one month, and seed stratified two months. These tests, as well as the germination records of the weighed seed in the sand and soil beds, show clearcut differences in viability between the different seed lots. Stratification of 36°F. improved germination in all but one lot (no. 4).

Seed weight also influenced percent germination. The mean weight of the 756 seed that germinated was 17.07 mg., whereas that of the seed that did not germinate was 15.57 mg., a highly significant difference of 1.50 mg. This relationship apparently held true for all seed lots, although too few seed failed to germinate in some lots to permit conclusive tests.

Since empty seed had been eliminated during the weighing process, it would appear that heavy white pine seed germinate better than light seed of the same origin. This conclusion is borne out by investigators working with other forest trees (3).

TIME OF GERMINATION

Not only do heavy seed germinate better than light seed, but they also germinate quicker. This is shown in Table 2. The seed that germinated 11–12 days after planting (on July 7 and 8) averaged 17.49 mg. On succeeding days, the mean weight of newly germinated seed decreased until, for the period following July 18 (22 days after planting), the mean weight reached a low of 14.26 mg.

TABLE 2.

RELATION OF SEED WEIGHT TO TIME OF GERMINATION

Days after planting	No. of seed germinated	Mean dry seed weight in milligrams
11–12	134	17.49
13–14	160	16.96
15–16	217	15.94
17–18	84	15.61
19–20	63	15.30
21–22	55	15.57
23+	43	14.26

The mean date of germination did not vary significantly between the sand and the soil. The period of germination was confined to nine days in the sand culture but lasted sixteen days for most lots in the soil bed, a few seed germinating as late as the second year.

The different lots varied slightly in their mean date of germination, but no correlation was noted between mean date of germination and either mean seed weight of lot or the locality from which the lot was collected. Lots 5 and 7 germinated earliest (July 9) and lots 3 and 9 the latest (July 16 and July 14).

ABNORMAL DEVELOPMENT

Of the 756 seed that germinated, 31, or 4 percent, developed abnormally. All but a few of these died before the end of the first growing season.

The most common type of abnormality was the failure of primary needles to grow after their appearance (12 plants). In two additional plants, the terminal shoots never appeared and the plants soon died.

An abnormality typical of lot 8 was the development of dwarf seedlings from light weight seed. Other types of unusual development, each observed twice, were the failure of the stem to grow in height although the cotyledons developed normally close to the ground, and the inability of the young plant to shed the seed coat, a failure ultimately causing death. Other plants merely developed poorly and ultimately died without any external deformity or attack by insects or fungi.

As the root systems of these abnormal plants were not examined, it is not known whether or not abnormal shoot development was related to abnormal root development.

INSECTS AND DISEASES

Despite disinfectants and other precautions, 35 plants were killed during the first season by insect and disease attack, and nearly as many additional during the next three years.

The nursery disease "damping off" accounted for at least 26 plants during the first few weeks of the first season. An indeterminate additional number undoubtedly damped off during germination before the plant reached the surface. No particular lot seemed to be more susceptible to the disease than any other.

The other external causes of mortality in the first growing season were drought and beetle damage to tender shoots immediately after germination. Two suspected species were identified by the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, as *Dysidius mutus* Say and *Anisodactylus merula* Germ., both members of the family Carabidae, the ground beetles.

Subsequent mortality was caused by damping off fungi, basal stem girdling by the pales weevil (*Hylobius pales* Boh.), winter consumption of two-year-old seedlings by field mice, and cold injury during the winter of 1942–43.

Mortality during the first growing season from all causes, both internal and external, was correlated with seed weight, the heavier seed having the higher survival. This relationship was true within the individual lots as well as for all lots taken together. The mean seed weight of the 66 plants that died was 14.30 mg., or 2.81 mg. less than the mean seed weight of all plants.

GROWTH OF SEEDLINGS

Each year, the effect of seed dry weight and seed origin on the dry weight of the shoot was studied by analysis of covariance. These analyses differed only in that fewer seed lots were available for sampling in the successive years, and more plants were sampled from each seed lot in each succeeding year (21 in 1943 as against 12 in 1941).

Seed weight was correlated with the size of the resulting plant each year. The regression of shoot weight on seed weight was linear and highly significant in all cases. In each succeeding year, however, the correlation coefficient between seed weight and shoot weight decreased; being 0.73 after the first year, 0.44 after the second, and 0.36 after the third. Thus the evidence is unmistakable that the effect of seed weight on plant weight becomes of less importance as the tree grows older.

External factors such as competition and soil nutrition were relatively uniform. Hence this growing lack of correlation between seed and plant size would appear to be due not to the external conditions of the experiment, but rather to hereditary, physiological, and other internal factors.

As heavy seed tended to germinate earlier than light seed (Table 2), the growing season of plants from heavy seed was materially longer than that of plants from light seed. The effect of this condition was to accentuate differences in size at the end of the first season; that is, the slope of the

regression of shoot weight on seed weight was greatest for one-year-old plants. Such an influence, however, should not affect the correlation coefficient for the regression.

The significance of the downward trend of the correlation coefficients is strengthened by the consistent values of other statistical measures in the three different years. In all cases, variations in mean seed weight and mean shoot weight between seed lots were highly significant and of a similar order of magnitude. Mean shoot weights of the different lots adjusted for variations in mean seed weights were of comparable significance each year. The implication is that hereditary differences in growth rates between the different seed lots were of similar magnitude each year. They did not tend to diminish or become more pronounced as the seedlings aged.

Although the individual seed weights were correlated with the shoot weights of resulting plants, the mean seed weights of the different lots were but poorly correlated with their respective shoot weights. (Statistically, the error of estimate of the regression of mean shoot weight on mean seed weight between the different lots was highly significant throughout). The individual lots, then, not only differed inherently in their mean growth rates, but also this difference was independent of the mean seed weight of the lot. The effects of seed weight and seed origin on growth are not interrelated.

The reduction in error due to the regression of shoot weight on seed weight was highly significant at all times. When this regression was calculated for individual seed lots, it was found in no case to differ from the regression based on the entire experiment. The relationship between seed weight and shoot weight, then, is a true species relationship and does not differ as between different seed origins within the species, at least in the case of white pine.

To compare the relative efficiency of the different samplings, the standard error of estimate of lot mean shoot weights was expressed as a percent of the overall mean shoot weight. This measure, an expression of the precision of the mean shoot weights of the different lots, was comparable for the three years, ranging from 4.6 percent to 6.9 percent.

As the shoot weight of a plant depends upon both its seed weight and its growth rate, the effect of varying seed weight must be removed if the actual growth of the various lots is to be determined. This calculation was made by adjusting the mean shoot weights of the different lots to the weights that might have been expected had all the plants developed from seed of the same weight (16.00 mg.). The adjustment utilized the regression of shoot weight on seed weight derived from the same data, and followed methods outlined by Snedecor (10). The use of this single correcting formula is quite legitimate, as the overall regression did not differ significantly from the regression for any one lot (10).

In Table 3 are given for each year of the experiment the adjusted shoot weights of the various lots arranged in approximate order of decreasing growth rates. The effect of seed weight is demonstrated by a comparison of the unadjusted and adjusted shoot weights for the first year. Actual

TABLE 3.

MEAN SHOOT WEIGHTS OF LOTS BY YEARS

Lot	Mean shoot weight in milligrams: Unadjusted first year	Adjusted[1] first year	Adjusted second year	Adjusted third year
7	79	78	1019	4790
1	62	77	1013	4440
5	95	72	918	4310
10	99	73	688	3640
4	71	69	—	—
6	53	69	898	3310
2	59	67	799	3610
3	55	61	818	—
9	73	67	651	—
8	49	59	676	—
Average	71	69	831	4020

[1]Adjusted to a mean dry weight of 16.00 mg., thus removing the effect of varying seed weights between lots.

mean shoot weights of the different lots varied from 49 to 99 mg.; but after the effect of seed weight had been removed, this variation was reduced to from 59 mg. to 78 mg. Much of the apparent variation in plant size between lots is, therefore, due to mere differences in seed weight rather than to actual differences in growth rate. Also, the largest plants (lots 5 and 10) did not grow as fast as lots 7 and 1, but merely started with larger seed. It is obviously necessary to take seed weight variations into account in growth studies of tree seedlings, as has been previously pointed out by Gast (5) and Mitchell (7, 8).

Differences in growth between lots were generally consistent, as between years. Lot 7 was the fastest growing in all three seasons, lot 1 following closely each year. The other lots were more or less consistent in their growth.

Little difference in growth rate between localities is apparent. Seed lots collected from Massachusetts (Harvard Forest) and from New York (Pack Forest) show similar growth. Lots from the White Mountains of New Hampshire are possibly slower growing. This difference may be due to the higher latitudes and altitudes from which the seed were collected. Not enough lots were tested, however, to permit accurate generalizations.

EFFECT OF GROWING MEDIUM

The discussion of growth thus far has been limited to data obtained from the soil bed. The same seed lots were also grown in a subirrigated sand culture.

In the sand bed, the plants were much larger at the end of the first year than were those grown in soil (87 mg. as against 69 mg.). Fewer plants were sampled from the sand, with the result that the data obtained were much less precise than those for the soil grown plants. As a result, the

sand values are less precise and less significant. For instance, the correlation coefficient between seed weight and shoot weight was 0.53 for the sand and 0.73 for the soil. All trends and relationships, however, held for the sand grown plants as well as for plants from the soil bed.

The regression of shoot weight on seed weight for both the sand and soil beds is shown graphically in *Figure 1*. The crooked lines represent the actual data grouped by classes. Both regressions follow similar trends despite the differences in fertility of the two media.

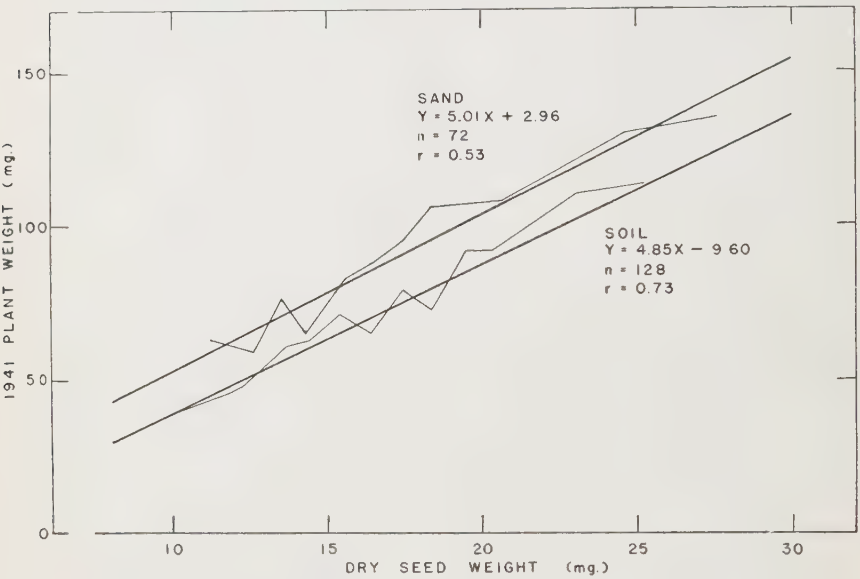

FIG. 1. The effect of seed weight on shoot weight in sand and soil beds.

Although the nutrient sand culture trials gave less precise results (due to poorer sampling) than did the soil bed trials, the evidence is that the effects of seed weight and seed origin on early growth hold for plants grown under varying nutrient conditions.

HEIGHT AS A MEASURE OF GROWTH

During the first two years of growth, the heights of white pine seedlings vary but little. Height is not a reliable measure of growth during this period. At the close of the third year in the present study, however, heights varied considerably. At this time, the effect of seed weight and seed origin on the height of white pine seedlings was studied by analysis of covariance. Trends and relationships were found to be generally the same as when shoot weight was used as a measure of growth, but values were of much less significance. For instance, the correlation coefficient between seed weight and height was 0.22, a barely significant value. The mean heights of the individual seed lots ranged from 5.1 to 7.7 inches.

Height is obviously not a satisfactory measure of growth when pine

seedlings are but three years old. It may, however, be an adequate growth measure of older trees. In hardwoods and other plants where the initial growth is largely linear, height is, in some respects, a satisfactory measure of growth as early as the first year (6).

RESERVE DRY WEIGHT

The seed coat makes up a considerable proportion of the weight of a seed. Since it is shed soon after germination, it does not nourish the seedling. If the dry weight of the seed coat is subtracted from the dry weight of the entire seed, a value is obtained which closely approximates the dry weight of the food reserves in the seed. This value has been variously described as "effective weight" (7) and "reserve dry weight" (5). Such a value is obviously more closely related to subsequent growth than is the dry weight of the entire seed. Nevertheless, the calculation of the reserve dry weight for each seed would appear to be unnecessary wherever it is directly proportional to seed weight.

To test this proportionality, seed coats were collected after germination, oven-dried, and weighed to the nearest hundredth of a milligram. When the reserve dry weight values thus obtained were plotted against seed dry weight, these two factors were found to be highly correlated. This relationship is shown in *Figure 2*, where the two parallel lines define the area in which practically all the 753 individual plotted points fell. Furthermore, similar regressions for each of the ten seed lots showed similar slopes and

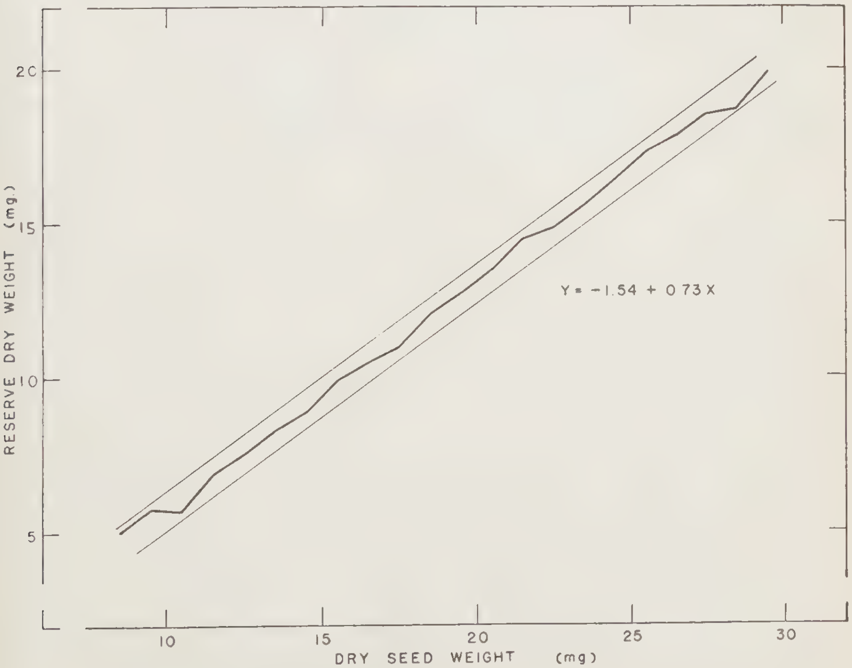

FIG. 2. Relation between reserve dry weight and seed dry weight.

elevations. Reserve dry weight, therefore, is not only highly proportional to seed dry weight, but this relationship also does not vary among various seed origins. The only cases where reserve dry weight was not proportional to seed dry weight occurred in partially filled seed. Several of these seed apparently gave rise to some of the abnormal plants discussed earlier.

Mitchell (7) previously had found reserve dry weight proportional to seed dry weight. The lack of proportionality found in the same data by Gast (5) appears to be due to his use of theoretically smoothed data rather than the actual values.

Twice in the present study parallel analyses of covariance were run, one analysis utilizing seed dry weight and the other, reserve dry weight. On both occasions, the correlation between reserve dry weight and shoot weight failed to differ significantly from the correlation between seed dry weight and shoot weight. Other values and relationships similarly held in the parallel tests. Furthermore, the regression of shoot weight on reserve dry weight was demonstrated to be identical with the regression of shoot weight on seed dry weight by converting the two regressions to similar terms. Since the results obtained from these parallel analyses did not differ significantly, no additional precision was obtained when reserve dry weights were used.

Reserve dry weight, then, is more closely related to subsequent growth because it closely approximates the weight of the food reserves in the seed. On the other hand, it is not necessarily more closely correlated with shoot weight than is seed dry weight. Because of the high degree of proportionality between reserve dry weight and seed dry weight, the calculation of the former is unnecessary, and the use of the latter is just as satisfactory in seed weight studies involving a single species. The use of reserve dry weights, however, is desirable when different species are to be compared, and in special cases such as when the seeds are known to be partially empty.

COMPOUND INTEREST GROWTH

Many formalized mathematical growth laws have been advanced to explain various growth data. A law frequently applied to growth of tree seedlings is the compound interest law (5). Various investigators have presented evidence to show that the size of pine seedlings at the end of the first growing season is roughly determined by the weight of the seed (initial capital) and the total effect of environmental and hereditary factors (interest rate). This follows the compound interest formula:

$$V_n = V_o \ (1.0p)^n$$

in which V_n is the accumulated capital; V_o, the initial capital; p, the interest rate; and n, the number of compounding intervals.

The argument has been advanced that, during a period of juvenile development, a plant increases in size at a constant rate of interest in close agreement with the compound interest law. From the above formula, it can readily be seen that the interest rate is measured by the ratio of accumulated capital to initial capital, provided that the compounding periods are of equal length. It follows that this ratio will remain constant for each

succeeding growing season if the plant is growing at a constant compound interest rate. Using the shoot weight at the end of the season as V_n and the weight at the start of the season as V_o, we find that the resulting ratios express the number of times that the plant increased in shoot weight during each growing season. Thus, the shoots of the white pine seedlings in the present experiment attained a size at the end of the first growing season roughly 8.5 times greater than that part of the dry food reserve of the seed which, on the basis of the shoot-root ratios immediately after germination, could be assumed to have gone into shoot growth (80 percent). During the second season, the shoots increased 12.2 times in weight, and, during the third, 4.5 times. This wide variation in the rate of growth from year to year, particularly the marked decrease during the third year, indicates that white pine seedlings do not consistently increase in shoot weight at a constant compound interest rate during the first three years of growth.

SEED ORIGIN

That seed origin affects the growth of white pine seedlings has already been demonstrated. Not only is seed origin important in its relation to growth, but it also affects other phases of the early development of white pine. It influences both the moisture content and habit of the resulting plants.

At the close of the first growing season, the moisture content of all harvested plants was calculated from their fresh and oven-dry weights. Analysis of covariance revealed that moisture content was completely unrelated to seed weight but that it was influenced both by seed origin and medium of growth.

Plants grown in the sand contained an average of 63.9 ± 0.05 percent moisture, whereas those grown in the soil bed contained an average of only 60.2 ± 0.03 percent moisture, a highly significant difference that was consistent for all lots.

The various seed lots differed in moisture content to a highly significant degree. Lot 3 had the highest moisture content (65.0 percent in sand and 61.8 percent in soil); while lot 2, also originating from the Harvard Forest, had the smallest amount of moisture (62.6 percent in sand and 59.7 percent in soil). The moisture contents of the various lots, while differing considerably, were apparently not related to the regions in which the seed originated, although the sampling from the different regions was insufficient to permit a generalization.

By the end of the second year, differences in appearance between the various seed origins had become quite apparent. These differences were due primarily to variations in needle length, the number of developed laterals, and the spasmodic occurrence of lammas shoots, secondary shoots formed after a mid-season period of dormancy.

To illustrate these differences in form, the largest, median, and smallest plants of each lot were photographed. In *Plate I,* the two fastest growing lots (7 and 1) are illustrated in the top row; the two lots with the largest seed (5 and 10) are in the middle row; and two of the slower growing lots

(6 and 2) are in the bottom row. The long needles and comparative absence of secondary growth give lots 5 and 10 a form quite distinct from that of lots 6 and 7, where the needles are relatively short and well-developed lammas shoots conspicuous.

At the end of the third growing season, few lammas shoots were observed (the late summer was quite dry); but variations in needle length and in the number of laterals resulted in distinct differences in appearance between the various lots. Needles were longest in lots 1 and 5 and shortest in lots 6 and 10. Many more laterals had developed on plants in lot 5 than in lot 1, the other lots having an intermediate number.

These differences in appearance are quite distinct, although somewhat difficult to measure quantitatively. They are obviously related to seed origin and apparently little affected by variation in seed weight.

SUMMARY

In order to study the effect of seed weight and seed origin on the early development of eastern white pine (*Pinus strobus* L.), one hundred seeds of each of ten different origins were weighed individually and grown under uniform conditions. At the close of each of the first three growing seasons, plants were removed, weighed, and their shoot dry weights statistically related to both seed weight and origin.

Heavy seed germinated better, germinated earlier, and survived in a higher proportion than did light seed from the same lot. Seed origin also affected germination and survival.

Shoot weight at the end of the first year was closely correlated to seed weight. As the plants grew older, however, the effect of seed weight on shoot weight diminished, but was still highly significant at the end of the third year. This relationship was the same for all the seed origins. Furthermore, the effect of seed weight on shoot weight was the same whether the plants were grown in a sand culture of high fertility or in a soil bed of moderate fertility. This result suggests that the effect of seed weight is independent of the nutrition of the seedlings.

Each seed lot consisted of seed of a single origin — seed collected from a single mother tree. The variation in growth between these lots was generally consistent from year to year and was highly significant at all times.

The effects of seed weight and seed origin on growth are not interrelated; that is, the mean seed weight of a lot gives no indication of the growth rate of that lot.

Much of the apparent variation in plant size between lots is caused by differences in seed weight rather than by differences in growth. The largest plants are not necessarily the fastest growing, but may merely have originated from the largest seeds. The influence of seed weight must be removed to bring out true differences in growth rate. This adjustment can be made by utilizing the regression of plant weight on seed weight derived from the same data.

The height of three-year-old pine seedlings is not a satisfactory measure of their growth.

Although the reserve dry weight of a seed is more closely related to subsequent growth than is seed dry weight, its use in the present experiment resulted in no increase in correlation between seed and shoot weight because of the high correlation between seed dry weight and reserve dry weight.

Shoot growth over a three year period failed to follow a constant compound interest rate of growth.

Plants grown in the nutrient sand culture contained more moisture than those grown in soil. Moisture content varied according to seed origin, but was independent of seed weight.

As early as the second year, differences in appearance between the various seed lots became noticeable. These differences resulted primarily from variations in needle length, the number of laterals, and the occurrence of lammas shoots.

Briefly, seed weight is related to germination, survival, and the early size of the plant. The correlation between weight and shoot weight diminishes as the plant ages, but is still noticeable after three years. Seed origin is related to germination, appearance, moisture content, and seedling growth. The influence of seed origin on plant size is as strong at the end of the third as at the end of the first growing season, in marked contrast to the constantly diminishing influence of seed weight. Both seed weight and seed origin, then, influence markedly the early development of eastern white pine.

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EXPLANATION OF PLATE I

Silhouettes of the smallest, median, and largest plants of selected lots at the end of the second year.

Harvard Forest,
Petersham, Mass.

Seed Weight and Seed Origin

PUBLICATION-DATES OF GAUDICHAUD'S BOTANY OF THE VOYAGE OF THE BONITE

IVAN M. JOHNSTON

THE PRESENT notes apply mainly to the publication-dates of the volume of folio botanical plates representing part of the botanical contributions of Charles Gaudichaud-Beaupré to the series of volumes entitled "Voyage autour du monde exécuté pendant les années 1836 et 1837 sur la corvette la Bonite, commandée par M. Vaillant." These botanical plates are noteworthy for abundance of analytic details, their high quality of execution, and the large number of South American and South Pacific species and genera based upon them. They were intended to illustrate the account of the collections made by Gaudichaud during his voyage on the Bonite. Distracted by controversies concerning his curious theories regarding plant anatomy, and finally hindered by ill health, he never completed the volume of text intended to accompany the volume of botanical illustrations. No descriptions or discussions of the many proposed new species and new genera which he had illustrated were ever published by him, and no information was ever supplied as to who had collected the specimens portrayed or as to exact localities where the specimens had been collected. It seems probable that most of Gaudichaud's plates were based on material he collected during the voyage of the Bonite. However, some of the species illustrated are neither known nor to be expected at the localities which the Bonite is known to have visited (cf. Johnston, Proc. Am. Acad. **71**: 13 [1936]); these must have been illustrated from material obtained by Gaudichaud on his previous voyages or from material of other collectors which Gaudichaud found in the herbaria at Paris. There is doubt as to the whereabouts of the specimens serving as the models for Gaudichaud's plates. Few if any of them appear to be in Paris. Brongniart, Ann. Sci. Nat. IV. **1**: 263 and 290 (1875), has suggested that they are in the Webb Herbarium, which was available to Gaudichaud in Paris before it was finally sent to Florence, Italy. Although without diagnoses, and lacking precise information as to the specimens on which they are based, the new species and most of the new genera proposed by Gaudichaud in his volume of plates are effectively published according to the Rules of Nomenclature. The Rules state that plates published prior to 1908 shall be considered equivalent to a diagnosis if accompanied with analytic details. Gaudichaud's plates have analytic details in great abundance. Practically all authors have accepted Gaudichaud's species as legitimately published. There has, however, been some difference of opinion as to the validity of the new genera published on the plates. A discussion of this latter matter has been published by Sprague, Kew Bull. **1928**: 395–397 (1928).

Some years ago, while working on a revision of the family Nolanaceae, I had my attention directed to the sixteen plates published in the Botany of the Bonite on which four new genera and nine new species of the Nolanaceae are founded. Matters involving priority forced me to make some attempt to date these plates. Only the most meagre and conflicting information regarding the dates of the work was available. Pritzel, Thesaurus 305 (1851), gives the work as beginning in 1839 and as still incomplete in 1851. Weddell, Arch. Mus. Hist. Nat. 9: 3 (1856), states that it was published between 1839 and 1846. In the second edition of his Thesaurus, p. 118 (1872), Pritzel dates the Botany of the Bonite as 1844–66. A note in the Journal of Botany, 39: 206 (1901), gives the dates of the plates as "1846–49?". Kuntze, Rev. Gen. 1: cxxviii (1891), states that all the plates were published from 1846–49 and, in any case, by 1851. No dates are to be found in the Atlas itself. The information reported in the present paper indicates that the plates began to appear in 1841 and were completely published in 1852.

Below I give all the significant data I have accumulated regarding the dates of publication for the botanical volumes reporting on the voyage of the Bonite. A number of questions are left unanswered, but, since it seems unlikely that I shall be able to add any missing details, it seems best to publish what I have discovered, with the hope that some other worker can complete the story. I have searched for reviews in contemporary literature and have examined nearly a score of copies of the Botany of the Bonite. A search for information at Paris gave few results. At London, however, I was most successful. At the Library of the British Museum (Bloomsbury) I was granted the very great privilege of consulting the old volumes in which the invoices of all books purchased by the Library were formerly pasted. Among these old invoices I found those of T. H. Baillière, who supplied the library with the volumes on the voyage of the Bonite. These invoices mention the livraisons by number and bear the date when they were sent from the London book-importer to the Library. Another source of information is the Bulletin of the Société de Géographie, Paris, which gives lists of books exhibited at sessions of the society. My references to this journal refer to the sessions at which parts of the Botany of the Bonite were exhibited. Unfortunately there are only a few references to the Botany of the Bonite in the Bibliographie de la France; these consist partly of official announcement of issuance (usually within a few weeks of actual publication) and partly of advertisements of the publisher, A. Bertrand. Assembling data from these and other sources, the following information becomes available in dating the livraisons of the botanical volumes of the voyage of the Bonite.

FOLIO BOTANICAL PLATES

Liv. I	Baillière invoice, June 5, 1841.
Liv. II	Bibliog. Fr., advertisement, Sept. 4, 1841. Baillière invoice, Oct. 2, 1841. Bull. Soc. Géogr., Dec. 3, 1841 (liv. 1 & 2).

Liv. III	Bibliog. Fr., advertisement, Dec. 4, 1841 (liv. 1–3). Bibliog. Fr., Dec. 18, 1841. Baillière invoice, March 19, 1842 Bull. Soc. Géogr., June 17, 1842.
Liv. IV	Baillière invoice, April 2, 1842.
Liv. V	Baillière invoice, Aug. 27, 1842. Bull. Soc. Géogr., Dec. 1842 (liv. 4 & 5).
Liv. VI	Baillière invoice, Oct. 8, 1842. Bibliog. Fr., Oct. 15, 1842.
Liv. VII	Bull. Soc. Géogr., Dec. 15, 1843 (liv. 6 & 7).
Liv. VIII	Baillière invoice, Nov. 4, 1843 (liv. 7 & 8).
Liv. IX	Bull. Soc. Géogr., April 12, 1844 (liv. 8 & 9).
Liv. X	——
Liv. XI	Bull. Soc. Géogr., Dec. 20, 1844 (liv. 10 & 11).
Liv. XII	Baillière invoice, May 16, 1844 (liv. 9–12).
Liv. XIII	Bull. Soc. Géogr., Jan. 14, 1848 (liv. 12 & 13). Arch. Sci. Phys. & Nat. Genève 8: 327 (1848) (liv. 11–13).
Liv. XIV	——
Liv. XV	Baillière invoice, March 15, 1845 (liv. 13–15). Bull. Soc. Géogr., April 1852 (liv. 14 & 15).
Liv. XVI	Baillière invoice, Oct. 23, 1847.
Liv. XVII	Baillière invoice, Jan. 16, 1849.
Liv. XVIII	Baillière invoice, Nov. 12, 1850.
Liv. XIX	——
Liv. XX	——
Liv. XXI	Baillière invoice, Jan. 9, 1852 (liv. 19–21).
Liv. XXII	——
Liv. XXIII	——
Liv. XXIV	Baillière invoice, June 8, 1852 (liv. 22–24).

QUARTO TEXT

"Livraison 12 et 13e."	Cryptogams by Montagne, Léveillé, and Spring; title-page dated "1844–46," but the introduction bearing the date May 20, 1846. Nov. Anal. des Voyages 4: 128 (Oct. 1846). Bibliogr. Fr., Nov. 7, 1846. Bull. Soc. Géogr., Dec. 18, 1846. Baillière invoice, Oct. 23, 1847.
Liv. 15 & 16.	Introduction by Gaudichaud, part one (pp. 1–354); title-page dated "1851." Baillière invoice, June 9, 1851. Compt. Rendu Acad. Fr. 33: 72, session of July 14, 1851.
Liv. 17 & 18.	Introduction by Gaudichaud, part 2 (pp. 1–442); title-page dated "1851." Compt. Rendu Acad. Fr. 33: 72, session of July 14, 1851. Baillière invoice, Jan. 9, 1852.
"Liv. complementaire."	Explanation of Plates, Vol. 3; title-page dated "1866." Bibliogr. Fr., Aug. 25, 1866. Accessioned at British Mus. Library Dec. 6, 1866.

The data just given indicate that the botanical publications relating to the voyage of the Bonite appeared as four, mostly double, livraisons of octavo text, and as twenty-four livraisons of folio plates. Most of these livraisons can be dated within six months. Unfortunately I have been able to assemble only fragmentary information as to the contents of the livraisons containing plates.

The only copy of the Botany of the Bonite which I have seen containing what appear to be accession-dates is that in the British Museum. On various plates of this copy are dates, either written or stamped. Accompanying the dates to the close of 1847 are also numbers (given in parentheses following the dates in the subjoined tabulation) which appear to be lot accession-numbers. By correlating the dates found on the plates with the dated itemized invoices of Baillière I had hoped to identify the livraisons to which the dated plates belonged. In three cases only are the dates on the plates definitely associated with the invoices. The red date-stamp on *plate 148* is also found on the invoice for Nov. 12, 1850, the red date-stamp on *plates 101–118* is also on the invoice for Jan. 9, 1852, and the red date-stamp on *plates 119–130* is also present on the invoice of June 8, 1852. The other accession-dates, however, would appear to correlate reasonably well with the dated invoices. The resulting tabulation given below, however, is so puzzling and in places so contradictory of facts which I have established from other sources that I distrust all conclusions to be drawn from it.

Plate	Plate marked	Baillière invoice	Livraison
11	Nov. 9, 1841 (186)	June 5, 1841	liv. 1
1	Jan. 5, 1842 (10)	Oct. 2, 1841	liv. 2
21	April 1, 1842 (132)	March 19, 1842	liv. 3
9	April 1, 1842 (152)	April 2, 1842	liv. 4
31	Dec. 8, 1842 (174)	Aug. 27, 1842	liv. 5
41	Dec. 8, 1842 (203)	Oct. 8, 1842	liv. 6
39, 40	Dec. 7, 1843 (294)	Nov. 4, 1843	liv. 7, 8
51	Dec. 7, 1843 (295)		
141	June 5, 1844 (303)	May 16, 1844	liv. 9, 10, 11, 12
71, 77, 79	June 12, 1845 (721–23)	March 15, 1845	liv. 13, 14, 15
81	Nov. 8, 1847 (141)	Oct. 23, 1847	liv. 16
88	July 13, 1849	Jan. 16, 1849	liv. 17
148	Dec. 12, 1850	Nov. 12, 1850	liv. 18
101–118	June 3, 1852	Jan. 9, 1852	liv. 19, 20, 21
119–130, title-page	Nov. 11, 1852	June 8, 1852	liv. 22, 23, 24

I have seen livraison-covers and have complete information as to the contents and livraison-number of all the volumes of octavo text and of six livraisons of quarto plates. I have given this information for the octavo text. The only livraison-covers of the plates seen by me are those in the copies of the folio at the Gray Herbarium and the Arnold Arboretum.

Those at the Arboretum (liv. 7, 8, 10, 11, 12) were purchased by me from a book-dealer in Paris. The livraison-covers in which the plates were distributed are undated and bear pasted on them a printed slip, without date, giving the livraison-number and the name and serial numbers of the plates it contained. The contents of the livraisons of which I have seen covers are as follows:

liv. 7	plates 141–150
liv. 8	plates 61–70
liv. 10	plates 71–80
liv. 11	plates of hydroids numbered 1–6
liv. 12	plates 81–91
liv. 20	plates 107–112

From the few livraison-covers seen it is clear that the plates were not issued in regular serial order, and, furthermore, that some of the livraisons contained only six plates while others contained ten. By extrapolation it is impossible to use the contents of the known livraisons to determine the contents of those unknown. While I am convinced that the Bonite plates will remain a bibliographic puzzle until someone discovers and reports on a complete set of livraison-covers, I believe it is possible by use of information at hand to work out a reasonable and more accurate and detailed dating of the plates than now available.

Plates 1–30. The first thirty plates are listed in the eighth Heft (August ?) of Oken's Isis for 1842, p. 625. Since we know that the first three livraisons did appear before 1842, it seems probable that the plates listed by Oken represent the first three livraisons, each containing ten plates.

Plates 31–70. According to Gaudichaud, Ann. Sci. Nat. II. 20: 208 (Sept. ?, 1843), *plates 42, 43,* and *44* are parts of liv. 5. This is as it should be if the publisher issued the plates serially in lots of ten, for *plates 31–40* would fall in liv. 4 and *plates 41–50* would make up liv. 5. I have seen a cover for liv. 8 which indicates that it contains *plates 61–70*. A cover for liv. 7 indicates that it contains *plates 141–150*. I have no information as to the contents of liv. 6. I suspect it may have contained *plates 51–60*.

Plates 71–100. A cover for liv. 10 shows that it contained *plates 71–80*. As shown by another cover, liv. 12 contained *plates 81–90*. According to a reviewer, Arch. Sci. Phys. & Nat. Genève 8: 327 (1848), liv. 12 and 13 were composed of plates showing chiefly new or little-known Urticaceae. All of liv. 12, *plates 81–90,* represents the Urticaceae. The decade of plates numbered *91–100,* except for *plates 99* and *100* (a fern and an aroid), also represents Urticaceae. The style of printing on *plates 91–100* agrees with that on *plates 81–90* and differs from other plates in the volume. It seems very probable, therefore, that liv. 13 contained *plates 91–100*.

Plates 101–130. At the British Museum *plates 101–118* are all stamped in red ink "3 JU 52." This same abbreviation is also stamped on

the Baillière invoice of Jan. 9, 1852, in which livraisons 19, 20, and 21 are listed. I have seen a cover for liv. 20, listing its contents as *plates 107–112*. This suggests that this group of livraisons probably contained only six plates each, and that liv. 19 contained *plates 101–106*, liv. 20 contained *plates 107–112*, and liv. 21 contained *plates 113–118*. Also at the British Museum, *plates 119–130*, as well as the title-page and table of contents, all bear the red stamp "11 NO 52," as does also the Baillière invoice of June 8, 1852, in which livraisons 22, 23, and 24 are itemized. It seems likely, therefore, that liv. 22 contained *plates 119–124*, liv. 23 contained *plates 125–130*, and liv. 24 contained the title-page and table of contents. *Plates 101–130* were evidently the last parts of the botanical folio to be issued. They were not printed by Bougeard, the printer of the other plates in the volume.

PLATES 131–150. Of this group of plates, *136–150* portray cryptogams and illustrate the reports prepared by Montagne and by Léveillé. These men prepared their reports promptly and were evidently annoyed at the delay in publishing their work. Many of their new species were published in periodicals because of the delay, and it appears that both issued advance privately circulated copies of the text which eventually appeared as part of the Bonite reports. Although numerically they are the concluding plates in the volume, *plates 136–150* were probably issued out of order to satisfy Montagne and Léveillé, whose work was in print. A cover for liv. 7 shows that it contains *plates 141–150*. Montagne, Ann. Sci. Nat. II. **19**: 238 (April 1843), complains that the original numbering of these plates, as *1–10*, had against his wishes been changed to *141–150*. Since the plates to illustrate Montagne's work were printed out of sequence, it seems probable that the plates numbered *136–140*, illustrating Léveillé's work, were given similar treatment. The style of headings on Léveillé's plates differs from that on Montagne's. I suspect that the plates of fungi, nos. *136–140*, appeared as liv. 9. This would leave five plates, nos. *131–135*, and five livraisons, nos. 14–18, unaccounted for. Possibly livraisons 14–18 each contained only a single plate.

It should be noted that livraison no. 11 of the botanical series of plates consists of six plates of hydroids. These zoological plates, numbered *1–6*, although issued in the botanical series, belong with the volume of "Zoophytologie" by Laurents. I have seen a cover of liv. 11. The fact that this zoological material appeared among the botanical plates was noted by contemporary reviewers, Arch. Sci. Phys. & Nat. Genève **8**: 327 (1848). Kuntze, Rev. Gen. **1**: cxxviii (1891), has also noted this fact.

The following tabulation summarizes my conclusions as to the contents of the twenty-four livraisons of folio plates. The dates are those established earlier in this paper.

Livraison	Plates	Date
1, 2, 3	1–30	1841
4	31–40	1841
5	41–50	1842
6	51–60 ?	1842
7	141–150 !	1843
8	61–70 !	1843
9	136–140 ?	1844
10	71–80 !	1844
11	Hydroids (1–6) !	1844
12	81–91 !	1844
13	91–100	1847–48
14, 15, 16, 17, 18	131–135 ?	1845–50
19	101–106	1851
20	107–112 !	1851
21	113–118	1851
22	119–124	1852
23	125–130	1852
24	title-page	1852

Arnold Arboretum,
Harvard University.

THE ARNOLD ARBORETUM DURING THE FISCAL YEAR ENDED JUNE 30, 1944

In the financial field the Arnold Arboretum closed the year with a substantial addition to its credit balance, this chiefly because of certain positions that were vacant because of the absence of some employees on duties connected with the war, and the fact that balances remained in specified budgetary items because of the impossibility of acquiring supplies and equipment due to current restrictions because of war conditions. In addition to the regular income of the institution, the Gifts for Cultural Purposes Fund received a total of $1835.00 in the form of unsolicited gifts from friends of the institution, while the extra-budgetary restricted Publication Fund was increased by $2858.00, mostly from similar sources; of this amount $700.00 represents a grant from the Board of the Netherlands Indies for use in publishing an English translation of Dr. Lam's "Fragmenta Papuana." A grant of $600.00 from the Penrose Fund of the American Philosophical Society, supplemented by a similar amount from the Milton Fund of Harvard University, was received for the use of the Director in connection with the preparation of a comprehensive *Index Rafinesquianus.* Grants totalling $3400.00 were received from the Milton Fund, the Penrose Fund, the National Academy of Sciences, and the Society of Sigma Xi, to finance a second season's work on the Alaska Military Highway by Dr. Raup and his associates. The only additions to capital were the annual accretions under the terms of gift to the James Arnold and Charles Sprague Sargent funds. The James R. Jewett Prize was awarded in August, but the Vieno T. Johnson prize was deferred.

Staff. — No changes were made in the technical staff, other than the resignation of Dr. Hui-Lin Li at the end of October, 1943. Leave of absence was granted to Dr. C. E. Kobuski, as he still remained in the military service. In the grounds group we are short-handed because several of our employees were drafted for military service, while others resigned to work in war industry plants. In general, as would naturally be expected, the labor situation was critical, and certain types of work had to be deferred or greatly curtailed.

Instruction. — The situation in 1944 approximated that of 1943, but with a further reduction in the number of graduate students. The accelerated instruction program remained unchanged and the limitation of staff members to giving a half-unit course every other year continues to be waived, and will so continue as long as war conditions prevail. The teaching program of staff members continues to be light.

Buildings, grounds, and horticulture. — The usual care has been given to the maintenance of all buildings, but the plantings have suffered,

due in part to a shortage of labor, and in part to the distinctly abnormal weather conditions. The past year was an exceedingly dry one, the rainfall deficiency approximating 12 inches. Because of little rain in November and December, and very little snow cover in the winter months, there was considerable winter injury to the root systems of small shrubs. While from the standpoint of temperature the winter was mild, zero temperatures being experienced but once, injury to various trees was manifest, probably because of the unusual winter dryness of the soil. The unseasonable late frosts of May 17 to 19 did some damage, killing flower buds and even the young leaves of some plants.

Because of the very dry weather the fire hazard in the Arboretum was unusually pronounced during the fall and spring months, about 75 fires occurring within the limits of the Arboretum. This was a decided increase over other years. While most of these were of minor importance, in two cases considerable damage was caused, chiefly among the Chinese spruces on South Street hill and among the dwarf conifers adjacent to the horseback trail. Regardless of the precautions taken during the spring and fall months in posting wardens, fires will occur, and unfortunately some do considerable damage. It is hoped that during the fall and winter months of the coming year some fire lanes can be established to prevent further damage in certain sections.

During the past year 179 species and varieties of woody plants were planted in the collections, many of these representing species not previously grown on the grounds. A total of 600 living plants, 18 lots of cuttings, and 22 packets of seeds were received. In the same period 1150 living plants, 65 lots of cuttings, and 16 packages of seeds were distributed.

It having been repeatedly demonstrated that certain varieties of Ghent azaleas are hardy under New England conditions, some 80 plants representing 40 different varieties were acquired and established on the Case Estate in Weston, and seedlings of 20 additional forms are being grown in the propagating house. While many of the desirable forms have long been grown in the Arboretum collections, many of the better varieties are rare or unavailable in the nursery trade, and it has seemed to us highly desirable to attempt to increase the supply. The favorable conditions at Weston have enabled us to initiate work on this task, and once the plantings are well established it is our plan to propagate the better varieties and to attempt to develop new ones by selection and hybridization. Furthermore, at Weston a collection of our new hybrid crab apples and ornamental cherries has been established by transfer of selected stock from the Arboretum nursery.

The Arnold Arboretum is very widely and favorably known for its extensive living collections of hardy ligneous plants. The original objective was to grow as many different forms as possible that are hardy under our climatic conditions. It now seems to be highly desirable to select the more outstanding horticultural forms. It is believed that the institution is now in a position to make an important contribution to American horticulture by

undertaking comparative studies in such groups as the lilacs, mock oranges, weigelas, roses, and others important in horticulture. The objective here would be to determine and to list the more outstanding forms or varieties from the large number of available ones and contrast these with the larger number which have proved to be of secondary importance. Such tasks take considerable time, but by concentrating on group after group, it will be possible to consider the various genera within a reasonable length of time. As an example, there are 108 *Philadelphus* plants in our collections with different names. A careful study of this group shows that only 35 of them can be considered as worthy ornamentals, although a very much larger number of named forms are offered in the trade. As studies of individual groups are completed, our findings can be passed on to both the amateur and the professional plantsmen, and thus we can increase the service of the institution to American horticulture.

Like all institutions of its type, the Arboretum has suffered from a shortage of labor. It has been necessary to curtail certain seasonal operations and to postpone other projects that involved much labor. The results are evident to the observer, but an improvement can scarcely be expected until conditions become more normal. One great need is a trained and experienced pruner, as many of the older trees on the grounds need attention and intelligent care. On the whole, in spite of the adverse labor conditions, much of the normal seasonal work has been accomplished.

In connection with the war effort the number of Victory gardens was considerably increased, as the use of the South Street nursery site, which was reconditioned last year, was granted to the Boston Victory Garden Committee, and all of the available space was utilized under the supervision of city authorities.

That the Arnold Arboretum strongly appeals to the general public is attested by the continued very large number of visitors, particularly at the height of the flowering season in May and early June. It is estimated that in spite of transportation restrictions there were at least 50,000 pedestrians in the grounds on lilac Sunday (May 21), and on the preceding Sunday approximately 35,000.

The War Effort. — Staff members have continued to render services important in one way or another to the prosecution of the war. The work of the Harvard Camouflage Committee, on which staff members of the Arnold Arboretum served, was concluded. The practicable and easily applied principles in reference to the selection of plant material for use in camouflage work were made available to the use of camoufleur schools in the form of two reports, the findings proving to be of distinct value. As one result of the publication and wide distribution of Technical Manual 10–420, "Emergency Food Plants and Poisonous Plants of the Islands of the Pacific," many inquiries have been received from service men operating in the Orient, scattered from Assam and Upper Burma to New Caledonia. Collections of botanical material are being received from the southwestern

Pacific, and so far it has been possible to report on each lot within a day after specimens were received. During the year the preliminary lists of species were prepared for a projected publication by the Navy Department on native woods for construction purposes in the western Pacific region, which was compiled in Washington. All of the illustrations were prepared at the Arnold Arboretum by an artist sent to Boston by the Navy Department, as the only comprehensive collections of specimens from the region covered in any United States botanical institution is in our herbarium. Our files of photographs, representing scenery in New Guinea, the Solomon Islands, China, Japan, Formosa, and other active and potentially active areas have been made available to representatives of the War and Navy Departments. Much assistance has been rendered to searchers for information, calling attention to maps, illustrations, topographical, climatological, and other data incorporated in technical botanical papers appertaining to Japan, the Bonin Islands, Formosa, the Philippines, the Netherlands East Indies, Papuasia, Micronesia, and Polynesia. The extensive bibliographic researches, carried out in the past, on the botanical publications appertaining to eastern Asia and the Pacific basin enabled us promptly to locate much needed information regarding specific areas. I have continued to lecture at the Army Medical School in Washington to each incoming group of trainees in the two months intensive refresher courses on tropical medicine.

During the year I prepared a chapter on plant life for "The Pacific World," edited by Fairfield Osborn, President of the New York Zoological Society. The volume was published in June, 1944, and a very large special edition is to be issued for distribution to service men throughout the Orient. The objective was a popular work on various phases of natural history, and about 30 individuals coöperated in supplying the data. The idea behind the preparation and publication of the volume was to give service men, particularly those who would have to remain in relatively quiet areas on garrison duty, some knowledge of their surroundings, indicating how they might utilize their spare time in developing interest in this or that phase of natural history. Now a series of volumes is projected on such subjects as animals, birds, insects, fishes, shells, plants, etc., each volume to be the work of an authority in each field. I undertook the preparation of the copy and illustrations for the projected "Plant Life of the Pacific World," and this is now nearly completed.

Botanical Survey of the Alaska Highway. — This project was mentioned in the last annual report. The field work in the summer of 1943 was eminently successful, and some of the results were of such a practical nature and of such special interest to the military engineers that it was suggested that the campaign be continued over a second season. In the summer of 1943 only a part of the road could be covered, the party going as far north as Whitehorse. The authorities wished to have that part of the road from Whitehorse to Fairbanks covered in a manner corresponding to the stretch from Edmonton to Whitehorse. The same privileges were granted for 1944

as attained for 1943, namely free transportation on the road and commissary privileges. Accordingly, Dr. Raup planned a field trip to northern Canada to cover the summer season of 1944, with the coöperation of the military authorities. This year the party consists of Dr. H. M. Raup of the Arboretum staff, with Mrs. Raup and their two sons, Dr. S. K. Harris of Boston University, these being the botanical members of the expedition, Mr. John H. H. Sticht, glacial geologist, and Mr. Frederick Johnson, archeologist. The party left Boston at the end of May, 1944, and will return about the middle of September. This year the botanical aspects of the expedition were financed by a second grant of $1500.00 from the Milton Fund of Harvard University, $1000.00 from the Penrose Fund of the American Philosophical Society, $500.00 from the Joseph Henry Fund of the National Academy of Sciences, and $400.00 from the Society of Sigma Xi. The expenses of Mr. Sticht are covered by a $900.00 grant from the American Geological Society, and those of Mr. Johnson by a grant of $1000.00 from the Peabody Foundation, Andover Academy. Details regarding field operations will not be available until next year, and this does not appear to be the time to discuss the practical results of the first season's operations, because of the nature of the case. Among the botanical results of the 1943 campaign was the preparation of approximately 15,000 botanical specimens, and it is anticipated that the collections to be made in 1944 will equal or exceed those secured last summer. The combined collections of the two season's campaign will be studied and reported upon as a unit when the determinations are completed. The extensive series of duplicates will be distributed to the larger botanical institutions of the United States, Canada, and Europe, as a part of our general exchanges. The construction of the emergency Alaska Military Highway made accessible a vast stretch of territory not previously explored from a botanical standpoint, and it was most fortunate that we had on our staff a widely experienced taxonomist and ecologist thoroughly familiar with northern Canada from his eight previous expeditions, who could take the lead, organize the two expeditions, and thus be the first botanist to visit the region traversed by this long highway that extends through the wilderness for a distance of 1500 miles. The 1944 trip is Dr. Raup's tenth botanical expedition into northern and western Canada.

Plant breeding. — The breeding work has resulted in a number of ornamental shrubs which have been selected for propagation and further tests. Among these is a semi-dwarf flowering cherry of the *subhirtella* type which blooms over a long period, a dwarf form of *Forsythia,* and a very compact globular form of *Malus*. Six of the better types of hybrid flowering crab apples have been propagated. Several of these have large purple flowers and attractive red fruits. Two spreading white-flowered segregates also have been selected for further tests. A few hybrids between American and Asiatic species of *Malus* have been obtained, but these have not yet flowered.

Breeding and cytological work with the Persian lilacs and their hybrids

has cleared up the taxonomic status of this group of lilacs and is of horticultural interest. As Mrs. McKelvey has suggested, *Syringa persica* and most of its varieties are of hybrid origin and are allied with *S. chinensis*, which is recognized as a hybrid between *S. vulgaris* and a Persian lilac. The only fertile true breeding Persian lilac is *S. persica laciniata*. This lilac crosses freely with *S. vulgaris* and with *S. pinnatifolia*. The first cross produces generally weak progeny, but the second cross produces hybrids of great vigor.

The artificially induced tetraploids of *Forsythia* and *Philadelphus* continue to show considerable promise. The tetraploid *Forsythia* is very hardy and has very large deep yellow flowers. Both tetraploids have been crossed with diploids to obtain sterile triploid forms.

Much of the breeding work at present involves wide species crosses which usually do not produce mature seed. If, however, the young embryos are cultured in nutrient agar, some of the crosses can be made to produce progeny. The culture technique has been part of our breeding program for the past five years. This work is now being done by Dr. Hally J. Sax.

Wood Anatomy. — Professor Bailey and Dr. Nast have continued their coöperative investigations of woody ranalian families with Dr. Smith. The last of seven papers dealing with the comparative morphology of the Winteraceae is now complete. A series of investigations dealing with the morphology and relationships of the much discussed ranalian genera *Trochodendron, Tetracentron, Illicium, Euptelea,* and *Cercidiphyllum* is nearing completion. Dr. Genevieve Dawson and Miss Lillian L. Nagel are studying the comparative morphology of the Escalloniaceae and Monimiaceae.

The Herbarium. — During the year 17,345 specimens were mounted — a number smaller than the annual average, due to the fact that inter-institutional exchanges have decreased because of the war, while our residue of unmounted old collections has been essentially eliminated. Of this number, 9,212 were inserted into the herbarium, which now includes a total of 617,944 specimens.

Because of the slackening of pressure upon our mounting staff, an arrangement was made with the Gray Herbarium whereby some of their accumulated Old World material was mounted at the Arboretum. Of the sheets mounted under this arrangement, 2,280 were returned to the Gray Herbarium, while 3,164 were retained at the Arboretum and accessioned as a transfer. Sections of the Arboretum herbarium were systematically examined by the mounters and desirable repairs were made.

A total of 26,822 specimens was received from other institutions or from individuals, by exchange, gift, subsidy, purchase, or for identification. As might be expected, the greater part of these came from North and South America. Important acquisitions include the 3,164 specimens mentioned above as transferred from the Gray Herbarium (among which are important

collections from the Belgian Congo, the Philippines, and Borneo), 2,518 Mexican specimens collected by G. B. Hinton, received from the New York Botanical Garden (subsequently transferred to the Gray Herbarium for selection of numbers lacking in the Hinton series at that institution), and 2,130 miscellaneous plants from the U. S. Department of Agriculture (including 870 specimens from the Canton region of China collected by E. D. Merrill but not previously distributed). Periodical shipments of Australian specimens continue to be received from Mr. C. T. White of the Brisbane Botanic Gardens, and Mr. William Greenwood continues his collecting for the Arboretum in Fiji. The largest and most important accession during the year, however, was the item of about 15,000 specimens of Canadian plants collected by Dr. Raup and his party along the Alaska Highway, as discussed in detail in a preceding paragraph.

The Arboretum distributed 11,745 specimens to other American institutions. Of these, 6,715 were sent in exchange and 4,378 were transferred to the Gray Herbarium, the remainder having been sent either as gifts or for identification by specialists. To the Gray Herbarium and the Ames Orchid Herbarium at the Botanical Museum were sent 412 illustrations for incorporation into the herbaria. Microfilm was distributed, under a special exchange arrangement, to the equivalent value of 177 specimens. The total number of specimens or their equivalent in mounted illustrations and microfilm distributed by the Arboretum was, therefore, 12,334. This number does not compare favorably with the usual annual figure, partly because of wartime restrictions on shipping.

Specialists and students in 13 American institutions called on the Arboretum for 21 loans, totalling 1,066 specimens. For the use of members of our own staff, 50 loans with a total of 1,758 specimens were received from 14 institutions.

To the catalogue of references to new species and other important literature dealing with woody plants, 3,266 cards were added; this catalogue, which is constantly consulted not only by our own staff members but also by visitors from other institutions, now contains 136,998 cards. No negatives were added to the collection representing types and other critical species during the year, the total number of such negatives remaining at 4,211.

As in recent years, routine herbarium work has been limited to the incorporation of clippings, typed descriptions, and illustrations, only a comparatively few specimens being added to the general collections because of the critical space situation. Mounted specimens are stored in family and generic order in cardboard boxes—an arrangement which must be continued until additional storage space in the herbarium is available. Although far from satisfactory, this arrangement permits staff members to consult newly mounted specimens with reasonable efficiency.

In addition to the usual number of routine identifications and reports, members of the herbarium staff continued studies in their special fields. Professor Rehder devoted a large part of his time to his Bibliography of

Cultivated Trees and Shrubs; for the purpose of checking various entities he visited libraries in New York, Philadelphia, and Washington. Dr. Smith continued his studies of tropical plants, completing a summary of the Elaeocarpaceae of New Guinea and working on various ranalian families in collaboration with Professor Bailey and Dr. Nast. Dr. Johnston devoted most of his time to a study of his very extensive collections from the plateau region of north central Mexico and adjacent parts of Texas. Four parts of his comprehensive catalogue were published during the year, and the manuscript on the families from the Caryophyllaceae to the Rosaceae is in an advanced state of preparation. Dr. Raup nearly completed his report on the extensive collections made by him in the Mackenzie Mountains, Alberta Province, in 1939, and has continued his work on mapping the ranges of species in Canada. Much time was of necessity devoted to the completion of plans for his 1944 trip along the Alaska Military Highway above noted. Mr. Palmer, continuing his studies of special groups in North America, devoted special attention to the genus *Crataegus* in the northeastern states. Dr. Allen, in connection with her work on the American Lauraceae, prepared revisions of certain Central American groups. Dr. Perry, in addition to continuing her studies of the New Guinean material of the Richard Archbold Expeditions, prepared a translation from the Dutch of Professor H. J. Lam's important "Fragmenta Papuana"; this translation will be published in a forthcoming number of Sargentia. Dr. Croizat devoted most of his time to a study of various groups of the Euphorbiaceae. Dr. Li left his position at the Arboretum in October to undertake work at the Philadelphia Academy of Sciences, having been the fortunate recipient of a Harrison Graduate Fellowship at the University of Pennsylvania. Previous to this he completed his study of several families of our large Chinese and Indo-Chinese collections. His project at Philadelphia will be an intensive study of the very large and complex genus *Pedicularis* as represented in China. My own work has been largely confined to checking the very extensive Index Rafinesquianus, reporting on current collections from the southwestern Pacific area, supplying information of various types to representatives of the armed forces, and the preparation of the manuscript for a projected semi-popular volume on the plant life of the Pacific region. Some work has been done in association with Dr. Perry on our accumulated collections of Papuasian plants, and certain assistance was rendered to Dr. Perry in connection with her translation of Dr. Lam's "Fragmenta Papuana" from the original Dutch version.

Linnaean microfilms. — This accession was discussed in the last annual report. Those films covering the Linnaean publications and manuscripts have been arranged so that they are now available for consultation. The task of preparing enlarged prints from the exposures representing herbarium specimens has been completed, there being approximately 16,000 of these prints. Their arrangement for purposes of consultation depends upon the completion of the new catalogue of the herbarium, the manuscript of

this being under preparation in London. A second set of prints is now being prepared for exchange purposes.

Bibliography. — Dr. Verdoorn has continued his work on the master file of the projected *Index Botanicorum*, and a booklet describing the aims and the scope of the project is in preparation. This is especially intended to supply basic information for foreign collaborators. Many references, including the names listed in the older botanical literature, were added during the year. He also completed and edited the extensive "Plants and Plant Science in Latin America" and "Science and Scientists in the Netherlands Indies." In the preparation of the data included in these two volumes, he had the coöperation of 170 individuals. He also edited volumes 12, 13, and 14 of his new series of plant science books, and has continued to be responsible for the central depository library for the Netherlands Indies in New York. Volume eight of his Chronica Botanica is dedicated to Charles Sprague Sargent, first Director of the Arnold Arboretum, whose unswerving interest over a period of 54 years resulted in the institution as we know it today. One of Dr. Sargent's prime interests was the library, which he consistently enriched, and which Dr. Verdoorn has found to be a veritable mine of information for the basic data needed in connection with the extensive *Index Botanicorum* project. The dedication is: "Arborum librorumque amatori Carolo Sprague Sargentio in arboreto arnoldiano bibliothecaque locupletissima pia anima pervigilanti hic chronicorum botanicorum tomus octavus dedicatur."

The Library. — Accessions to the library during the past fiscal year amounted to 250 bound volumes and 140 pamphlets, making the total number of bound volumes 45,563, and of pamphlets 13,462. Approximately 595 cards were added to the main catalogue, 250 of them containing bibliographical data, and some 622 slips were added to the files which supplement the printed author and subject catalogue of the library. Interlibrary loans continued to be very numerous, and many orders for photostats and microfilms were received. Most of our forestry periodicals, numbering about 3,600 volumes, were deposited in the library of the Harvard Forest in Petersham. Our large collection of photographs was carefully checked through by the Navy Department, and many were sent on loan to Washington to be reproduced.

Atkins Institution of the Arnold Arboretum. — The limitations mentioned last year still prevail in reference to this unit, so that about all that could be done was to maintain and extend the plantings at Soledad. Difficulties have been encountered because of the impossibility of securing certain supplies and because of the extremely dry weather that characterized the past year, as well as the preceding one, and because of the necessity of increasing wages. The small stream which supplied water for irrigation purposes failed in two successive years at the height of the dry season, but

spring sites were known to be present in the cane fields assigned to the use of the garden in 1939, and three wells developed on these sites have provided sufficient water for present needs. It became necessary, however, to rearrange certain pipe lines and pumping installations. Additional plantings have been made in the palm section. During the year 195 living plants and 346 packages of seeds were distributed, and 20 living plants and 176 packages of seeds were received from abroad.

Publications. — Four numbers of the Journal appeared as usual, and a fourth number of Sargentia, including papers by Dr. A. E. Porsild (National Herbarium of Canada, Ottawa) on the flora of the continental Northwest Territories of Canada and by Dr. Raup on the willows of the Hudson Bay region and the Labrador Peninsula, was published. A fifth number of Sargentia, containing Dr. Perry's translation from the Dutch of Professor Lam's "Fragmenta Papuana," is now in press. Arnoldia was issued as usual. A bibliography of the published papers by staff members and students follows.

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Synonyms are printed in *italics;* new names in **bold-face** type.

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